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Yoshida

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(54) **IMAGE FORMING APPARATUS WITH MECHANISM CAPABLE OF MOVING TRANSFER DEVICE WITH RESPECT TO TONER IMAGE CARRIER AND IMAGE FORMING METHOD FOR MOVING TRANSFER DEVICE WITH RESPECT TO TONER IMAGE CARRIER**

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G03G 15/16 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/1605*** (2013.01); *G03G 2215/0129* (2013.01); *G03G 2215/0193* (2013.01); *G02G 2215/00059* (2013.01); ***G03G 15/0131*** (2013.01); ***G03G 15/5058*** (2013.01)
USPC **399/66**

(58) **Field of Classification Search**
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USPC 399/66
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,729,788 A *	3/1998	Hirohashi et al.	....	399/66
6,246,844 B1 *	6/2001	Shiba	....	399/49
6,389,242 B1 *	5/2002	Watanabe	....	399/45
6,862,421 B2 *	3/2005	Choi	....	399/302
7,239,835 B2 *	7/2007	Ito et al.	....	399/313
7,274,888 B2 *	9/2007	Tomizawa	....	399/49

(Continued)

FOREIGN PATENT DOCUMENTS

JP	8-248787	9/1996
JP	8-314297	11/1996

(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 13/402,290, filed Feb. 22, 2012, Ken Yoshida.

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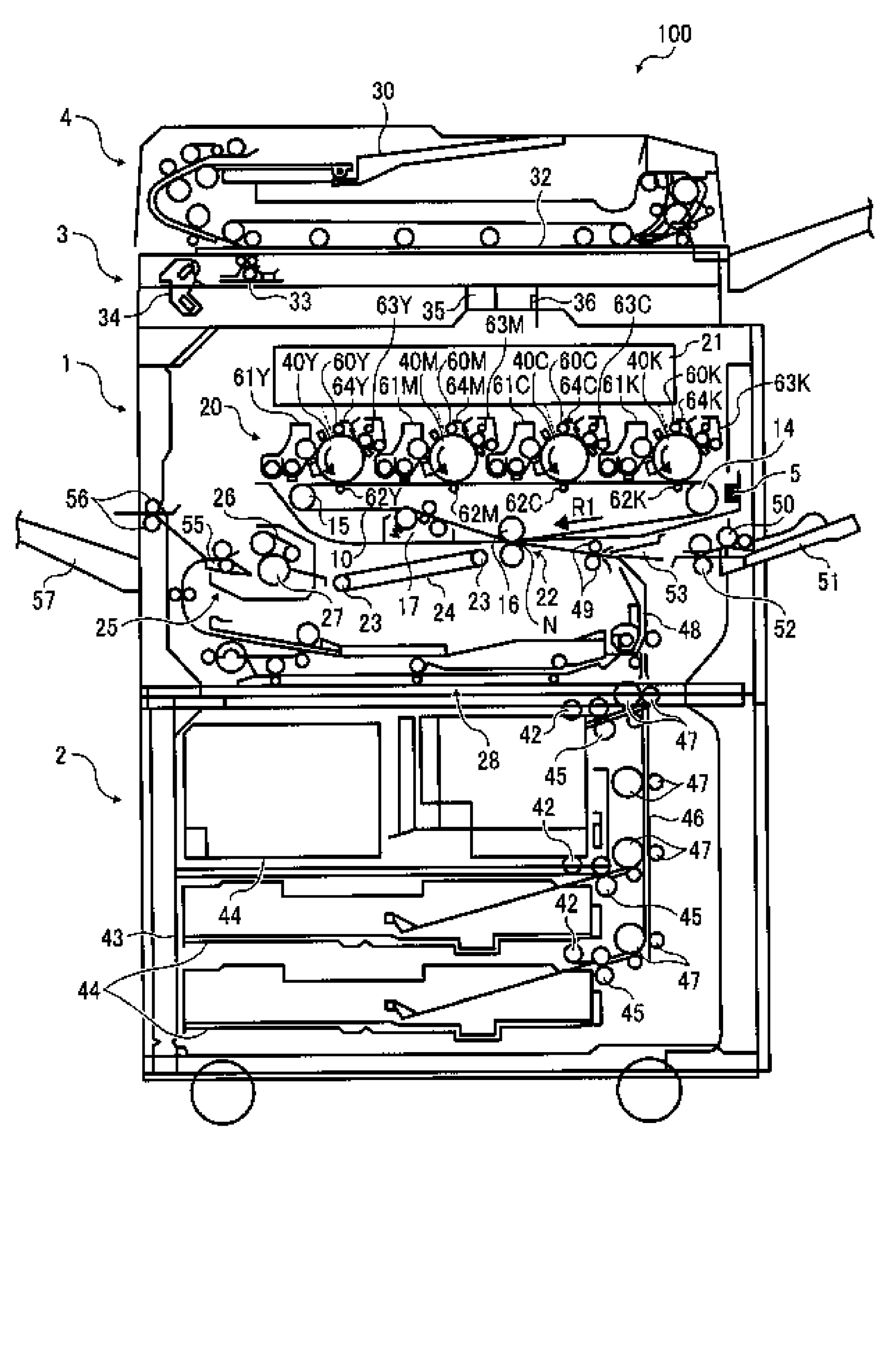
(57) **ABSTRACT**

An image forming apparatus includes a transfer device separator that moves a transfer device between a contact position and a first isolation position within a shortened time. At the contact position, the transfer device contacts a toner image carrier. At the first isolation position, the transfer device is isolated from the toner image carrier with a first interval therebetween. A controller controls the transfer device separator to move the transfer device to the contact position as first to third toner images and a blank section between the first toner image and the second toner image carried by the toner image carrier pass through a transfer region and to the first isolation position as a toner patch section between the first toner image and the second toner image carried by the toner image carrier passes through the transfer region.

19 Claims, 10 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,813,662	B2 *	10/2010	Muto et al.	399/66
8,107,848	B2 *	1/2012	Nozawa et al.	399/101
8,290,413	B2 *	10/2012	Kobayashi et al.	399/299
2004/0136760	A1	7/2004	Yoshida et al.	
2005/0013636	A1	1/2005	Sawai et al.	
2005/0147424	A1	7/2005	Kato et al.	
2005/0254853	A1	11/2005	Yoshida	
2006/0062593	A1 *	3/2006	Takahashi	399/121
2007/0127960	A1	6/2007	Yoshida	
2007/0134014	A1	6/2007	Kato et al.	
2007/0280748	A1	12/2007	Yoshida	
2008/0088883	A1	4/2008	Yoshida	
2008/0279589	A1 *	11/2008	Muto et al.	399/170
2009/0016784	A1	1/2009	Yoshida	
2009/0196661	A1	8/2009	Yoshida	
2009/0232539	A1 *	9/2009	Nozawa et al.	399/101
2010/0017019	A1 *	1/2010	Andoh et al.	700/229
2010/0080589	A1 *	4/2010	Yoshioka	399/45
2010/0080631	A1 *	4/2010	Ogiyama et al.	399/308
2010/0098446	A1 *	4/2010	Ishikawa et al.	399/51
2010/0266300	A1	10/2010	Yoshida	
2011/0103810	A1	5/2011	Yoshida	
2011/0222920	A1 *	9/2011	Kobayashi et al.	399/299
2011/0249992	A1	10/2011	Yoshida	
2012/0230706	A1 *	9/2012	Yoshida	399/27
2013/0077984	A1 *	3/2013	Yoshida	399/66

FOREIGN PATENT DOCUMENTS

JP	2001-305823		11/2001	
JP	2001-312154		11/2001	
JP	2002-123052	*	4/2002	G03G 15/00
JP	2006-308816		11/2006	

* cited by examiner

FIG. 1

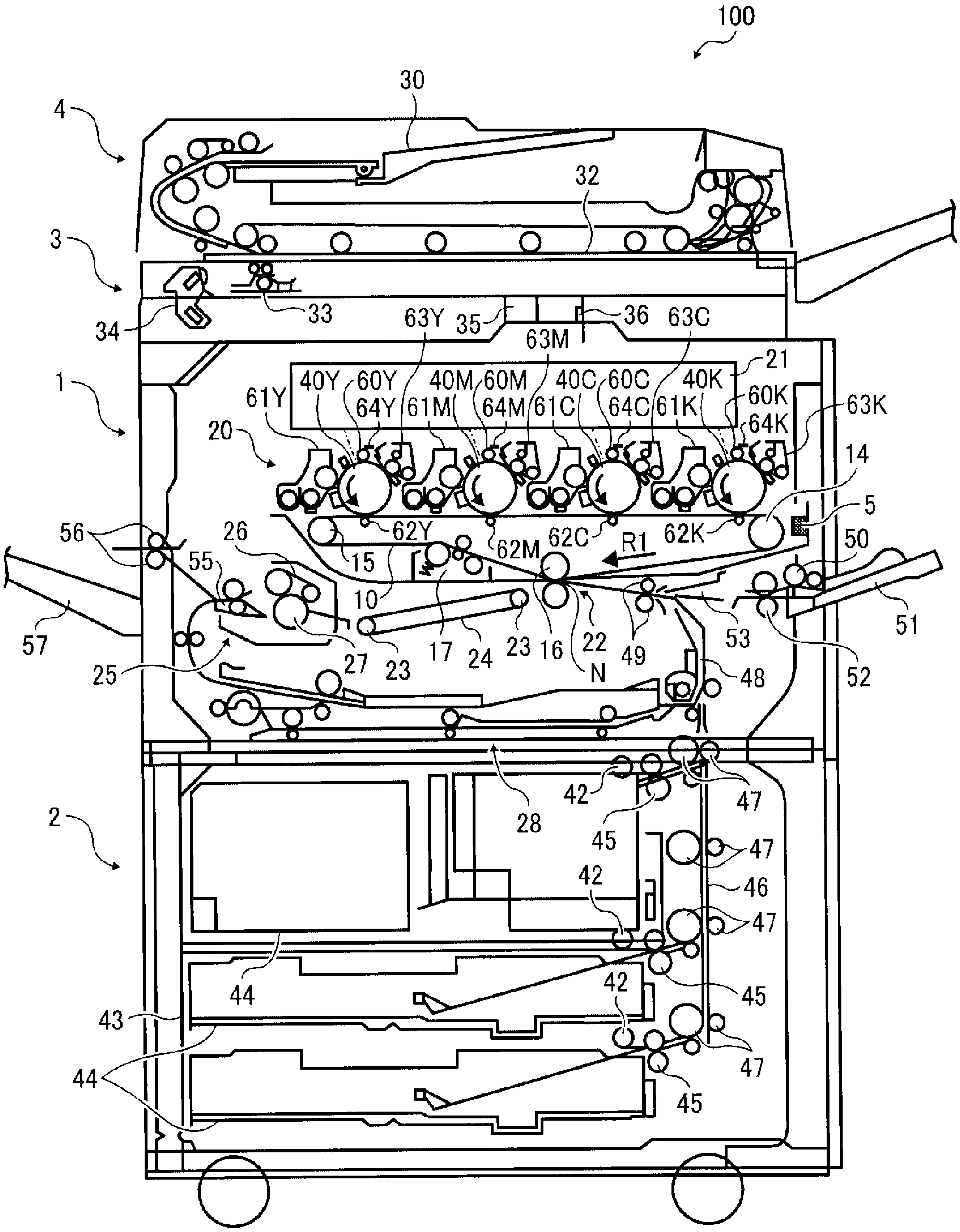

100
30
4
32
3
33
34
35
36
63Y
63C
63M
1
21
40Y
60Y
40M
60M
40C
60C
40K
60K
61Y
64Y
61M
64M
61C
64C
61K
64K
63K
20
14
5
56
26
62Y
62M
62C
R1
62K
50
55
15
10
57
27
23
17
24
23
16
22
49
53
52
51
25
N
48
28
42
47
45
2
46
44
43

FIG. 2

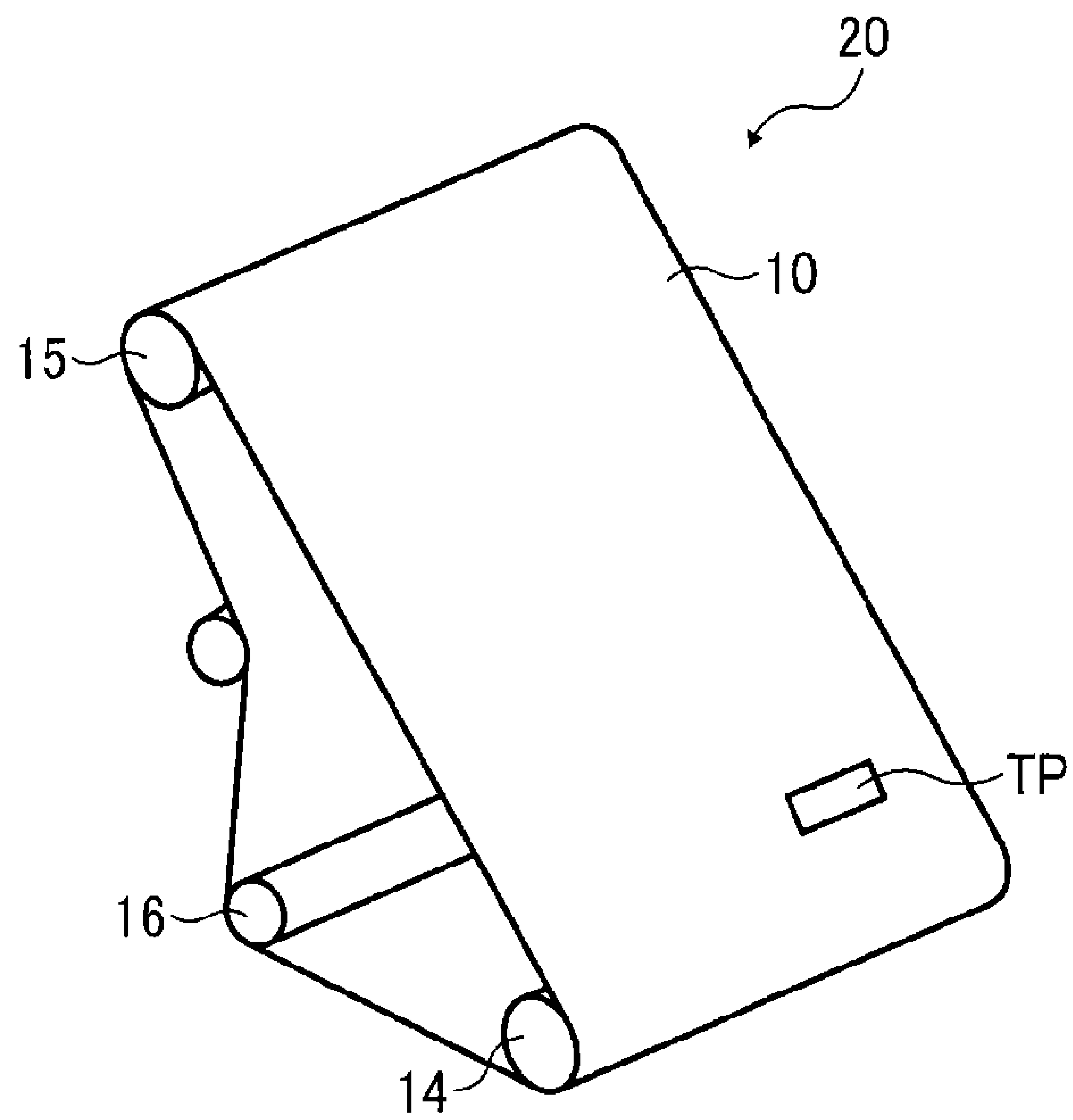


FIG. 3

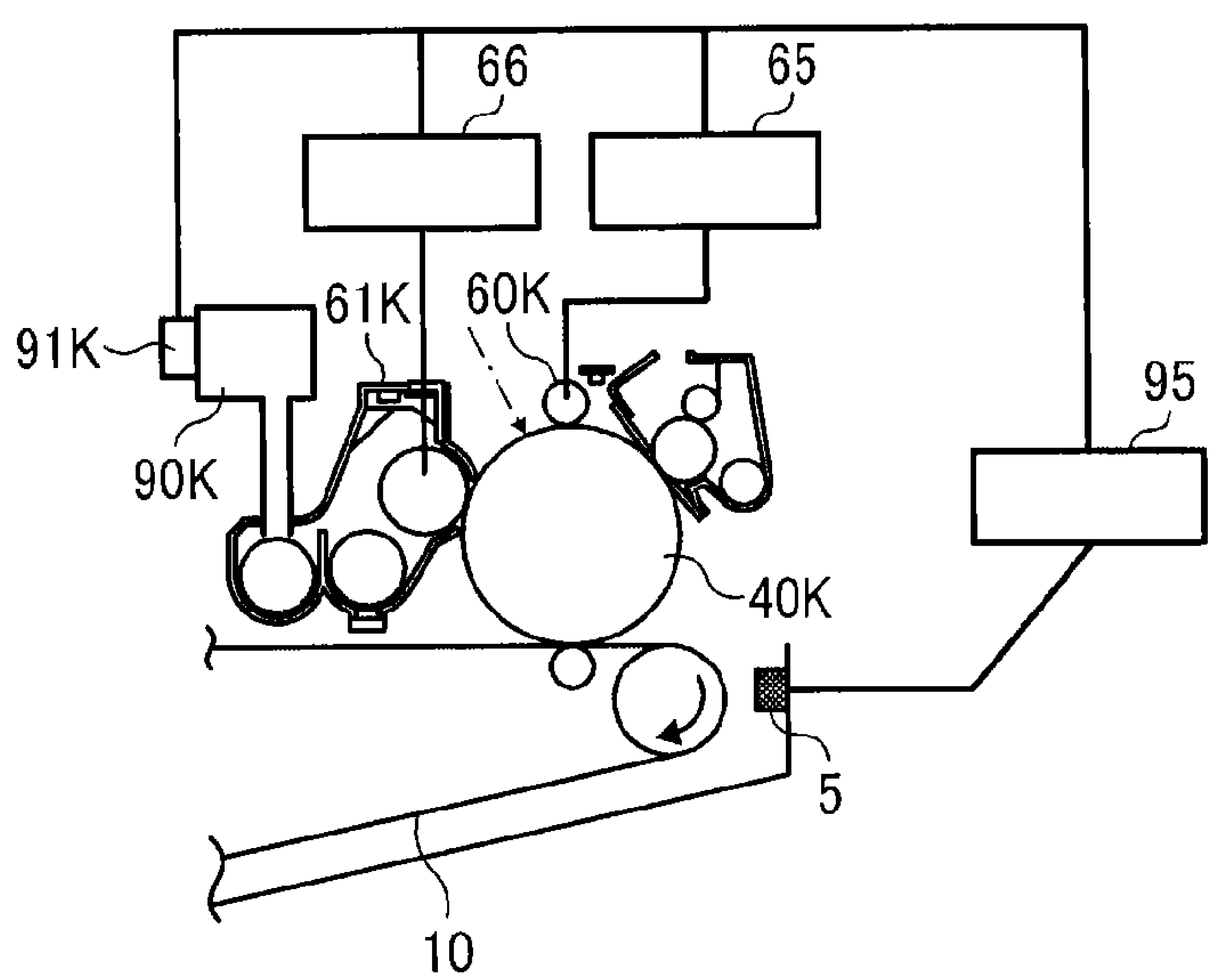


FIG. 4A

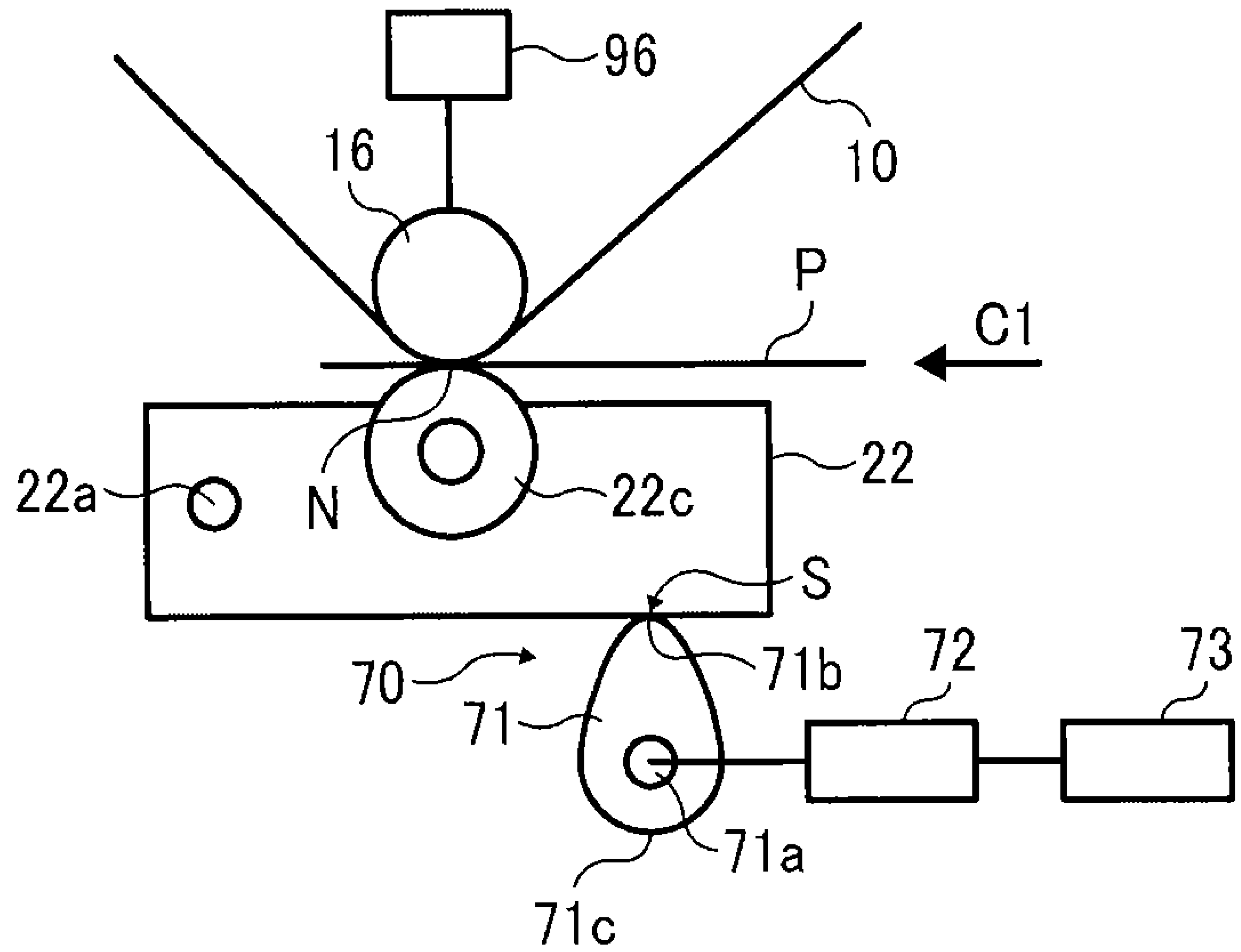

96
16
10
P
C1
22a
N
22c
22
S
70
71
71b
72
73
71a
71c

FIG. 4B

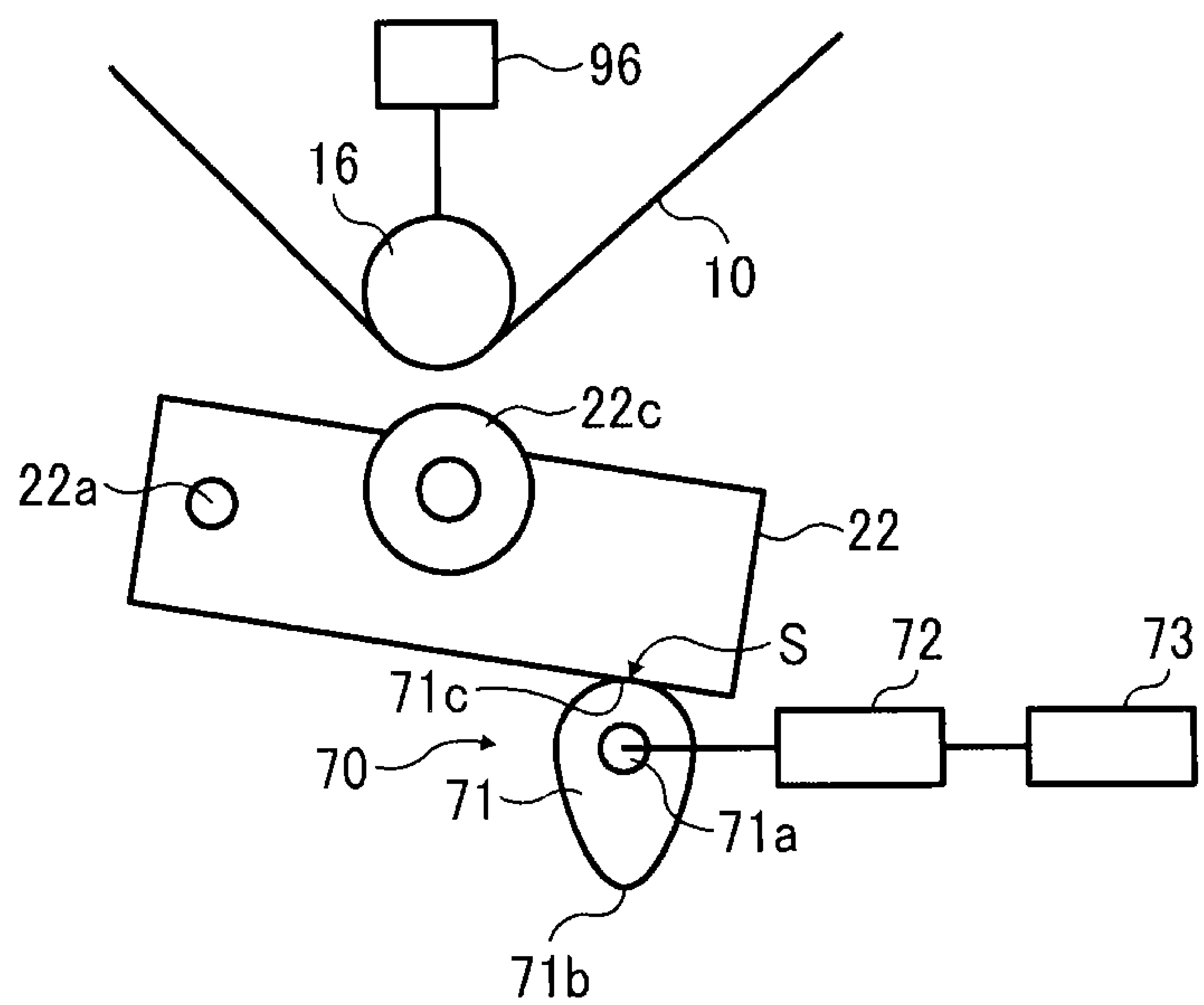

96
16
10
22c
22a
22
S
72
73
71c
70
71
71a
71b

FIG. 5

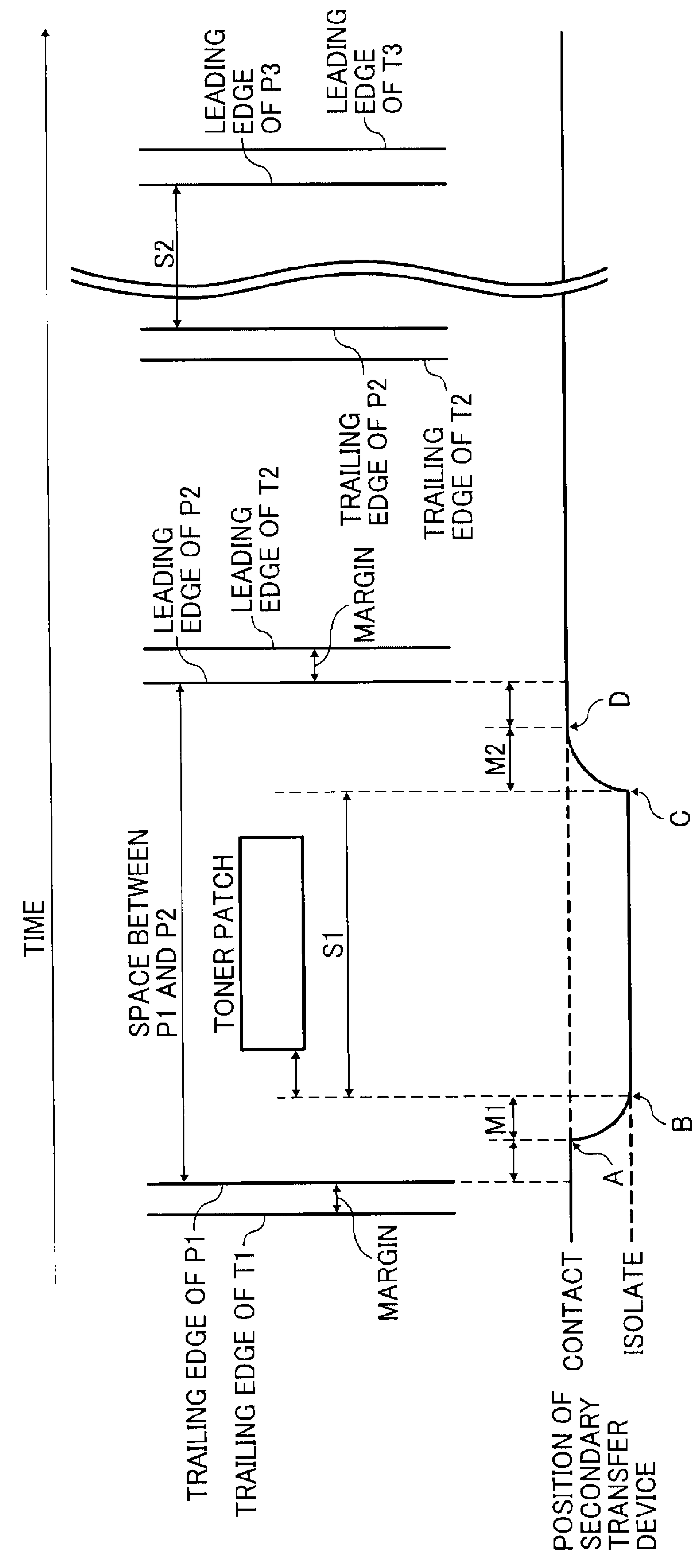

TIME
LEADING EDGE OF P3
LEADING EDGE OF T3
S2
TRAILING EDGE OF P2
TRAILING EDGE OF T2
LEADING EDGE OF P2
LEADING EDGE OF T2
MARGIN
SPACE BETWEEN P1 AND P2
TONER PATCH
S1
M2
M1
D
C
B
A
TRAILING EDGE OF P1
TRAILING EDGE OF T1
MARGIN
POSITION OF SECONDARY TRANSFER DEVICE
CONTACT
ISOLATE

FIG. 6A

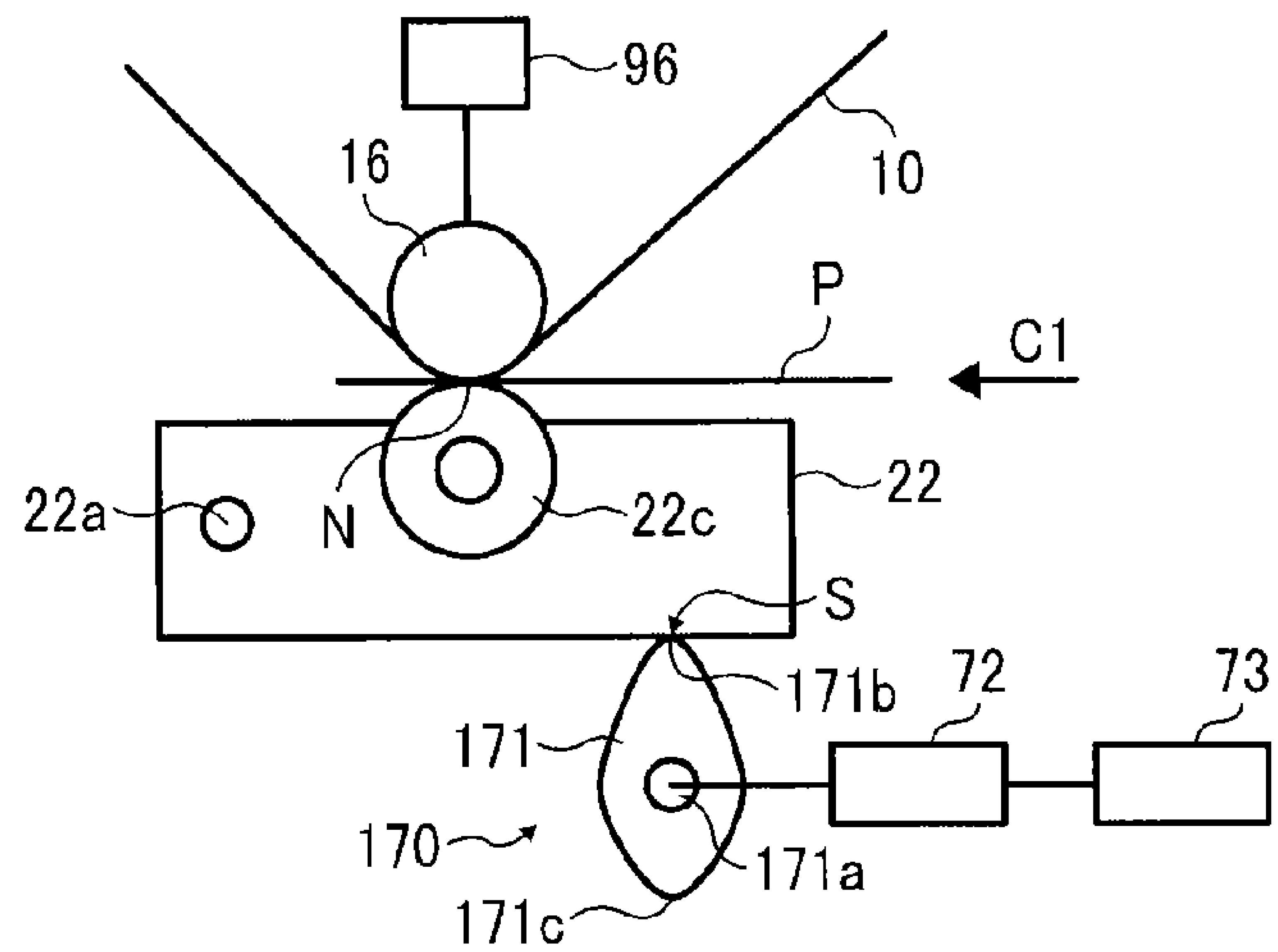


FIG. 6B

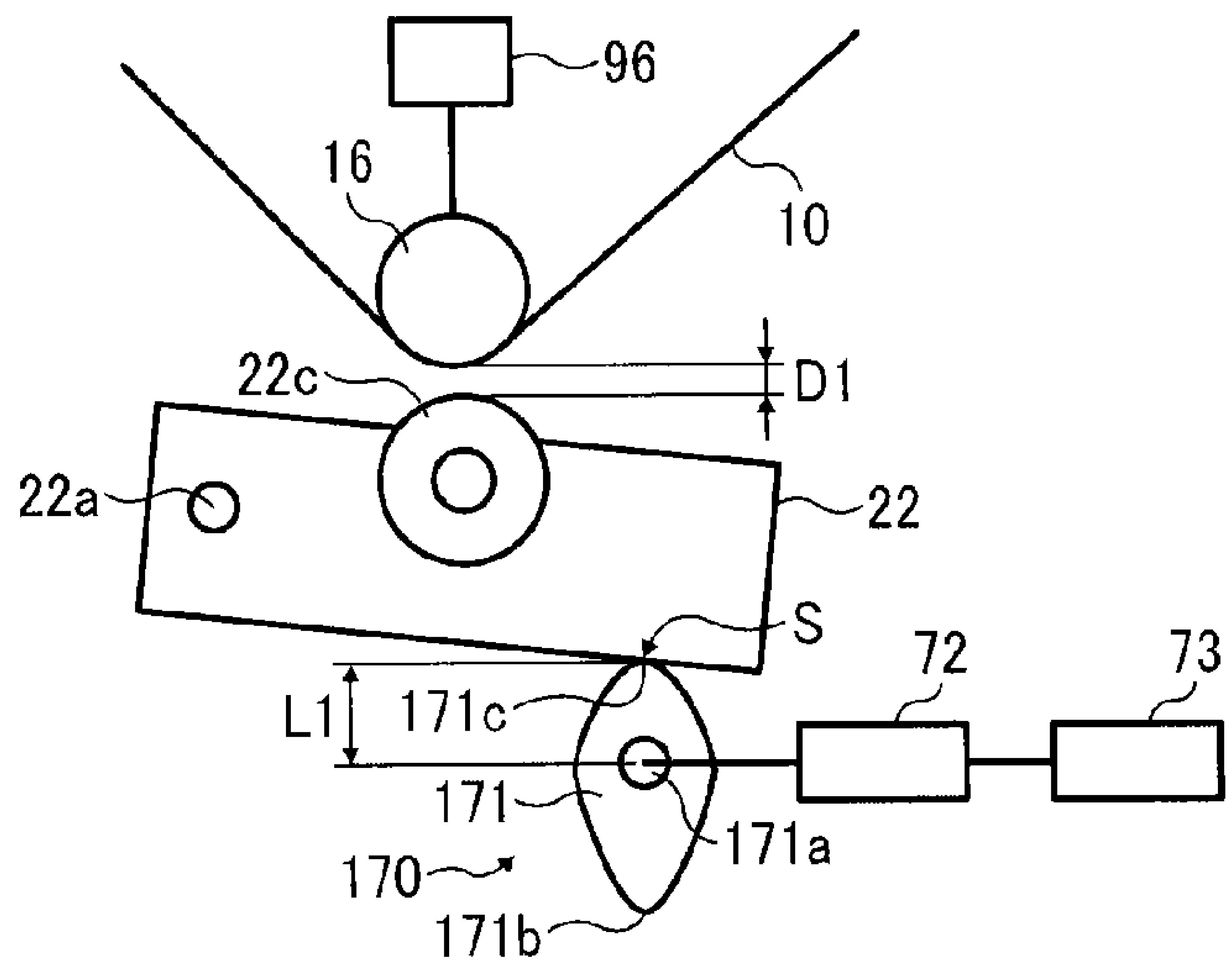


FIG. 6C

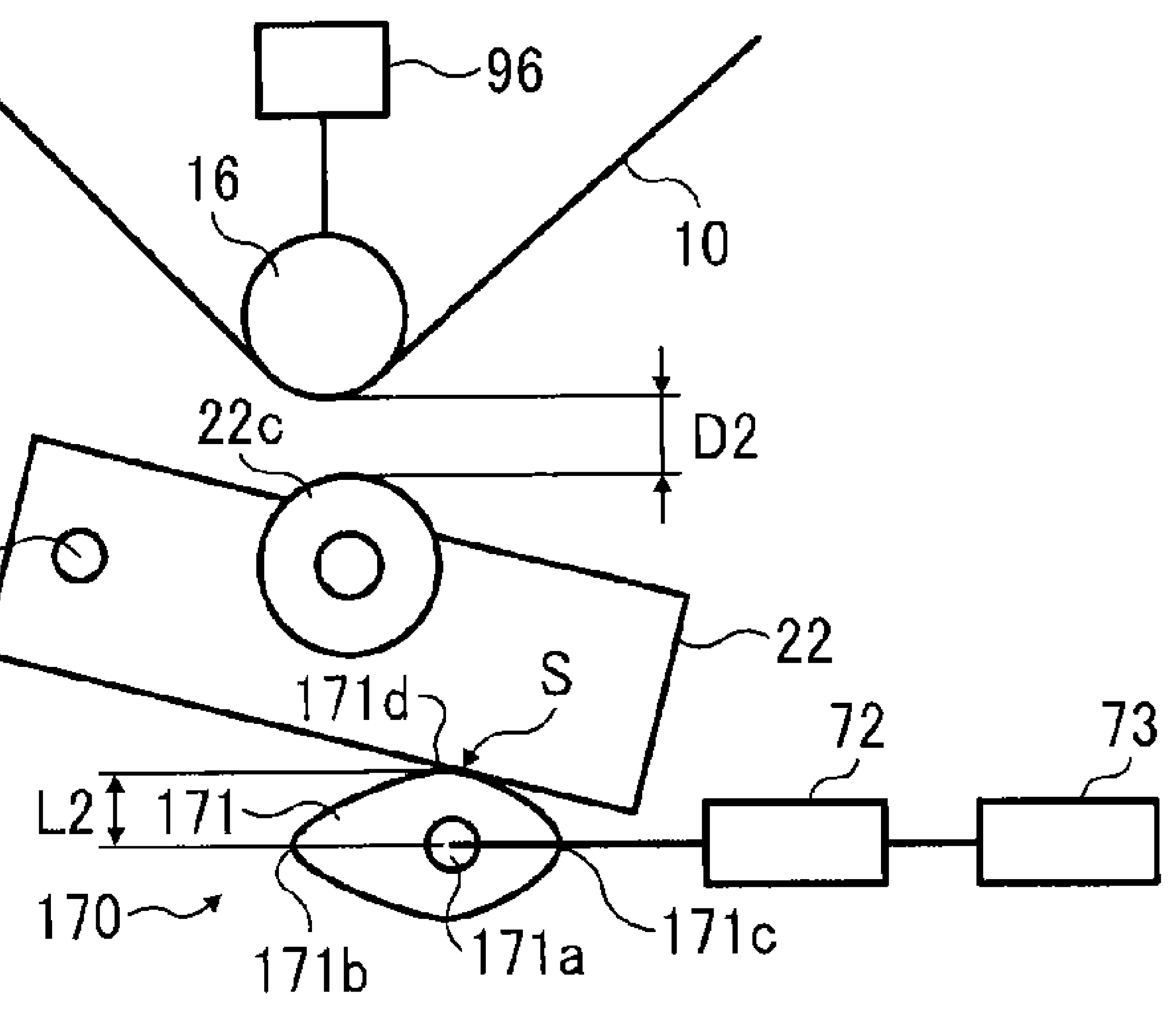


FIG. 7A

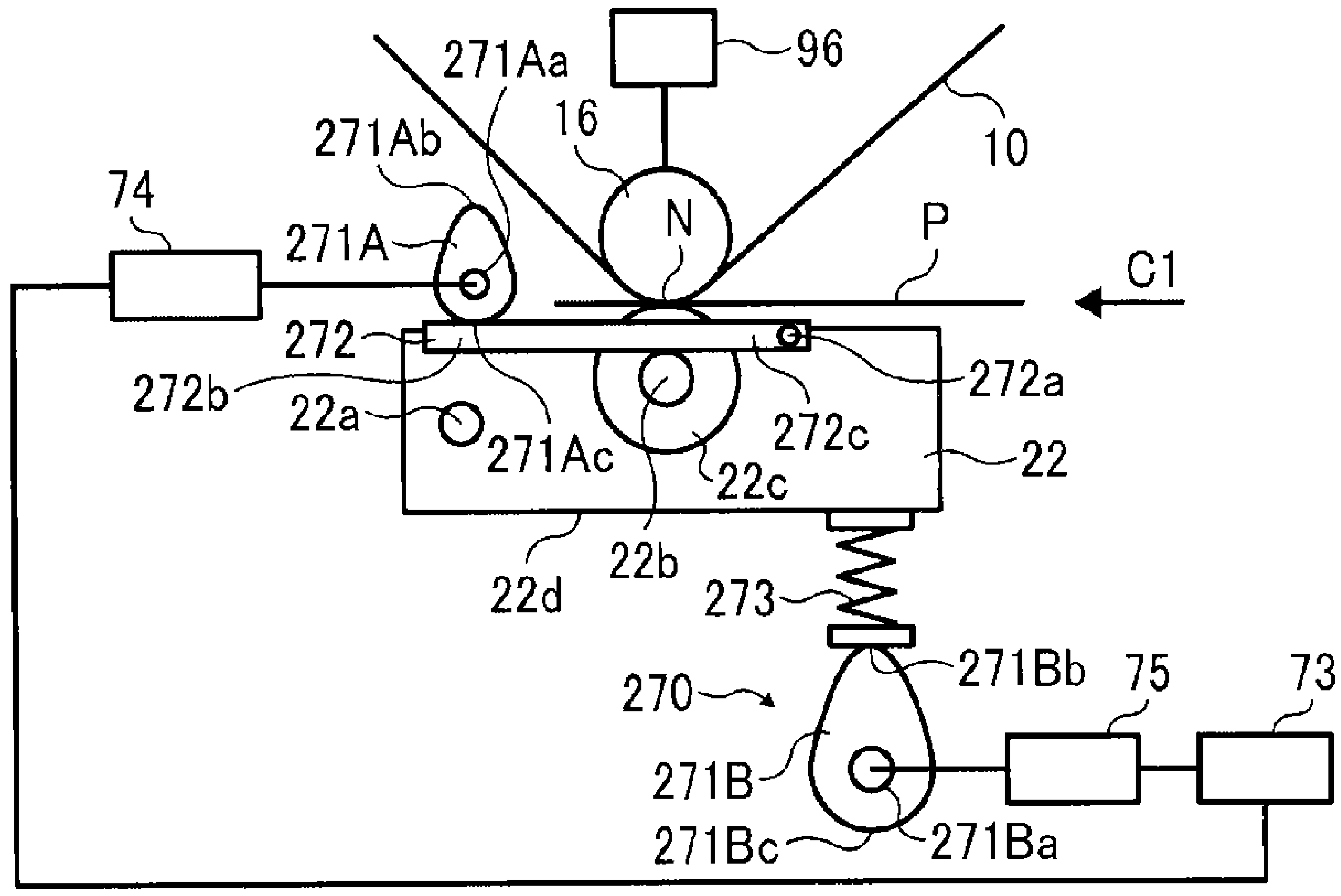


FIG. 7B

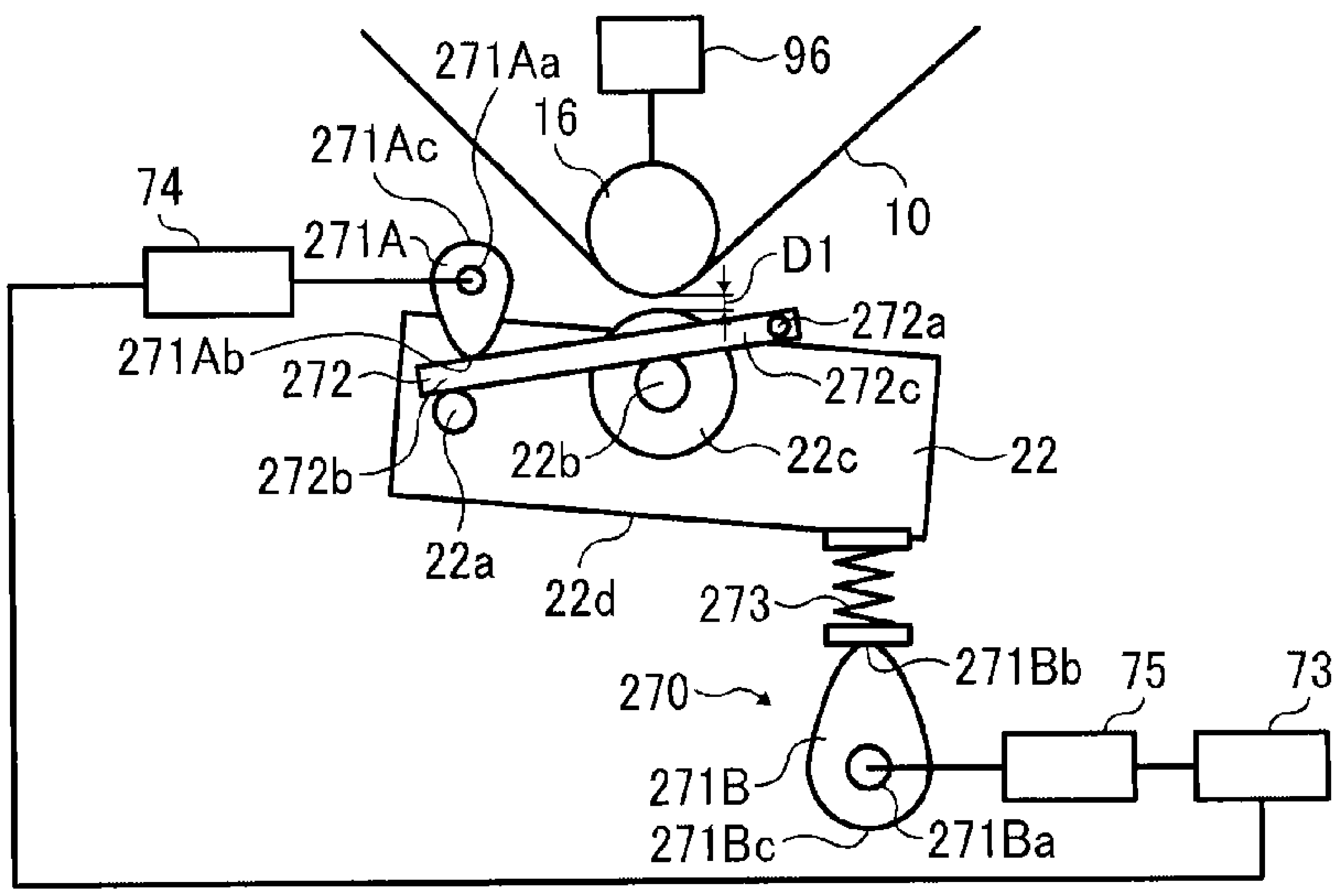


FIG. 7C

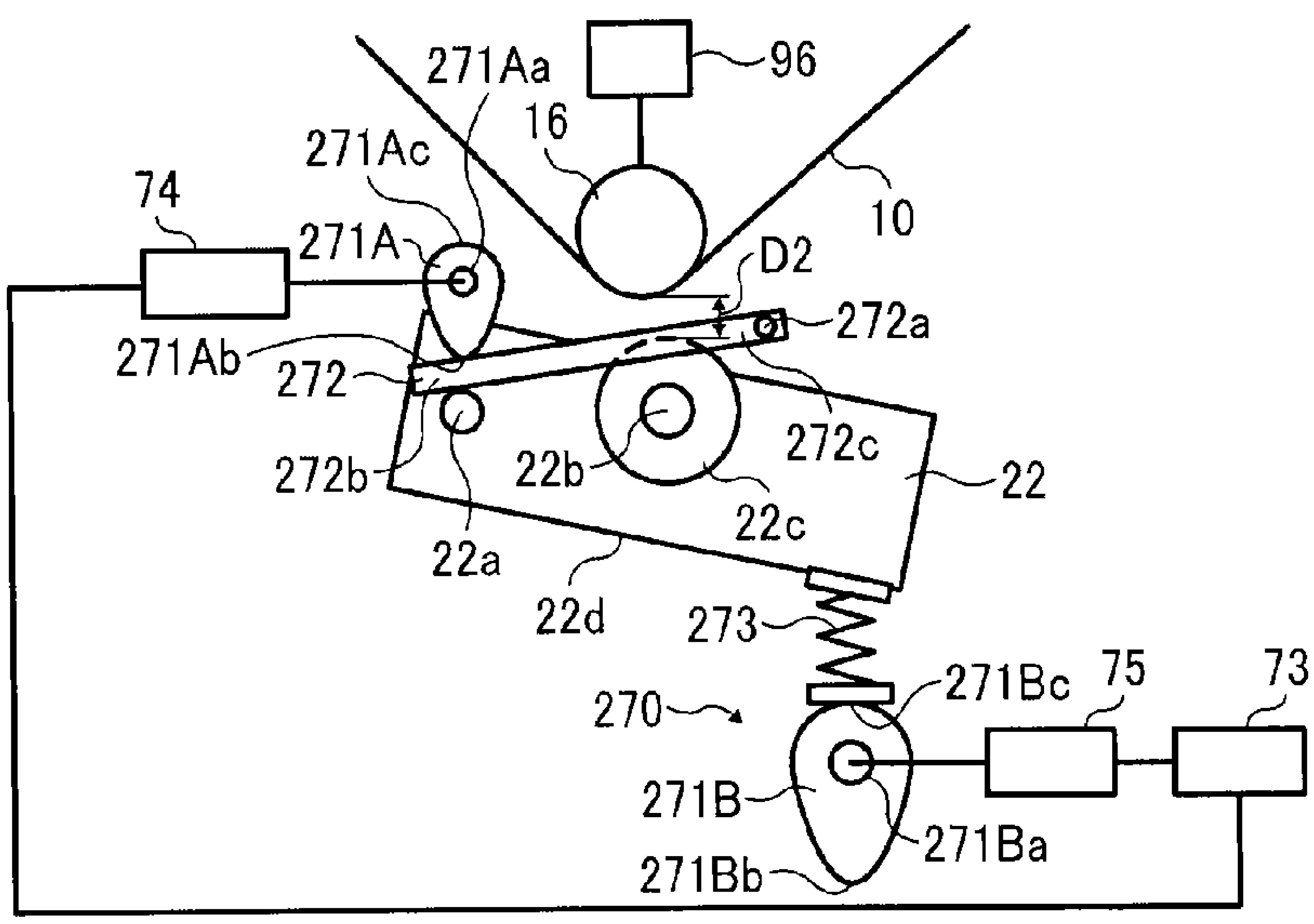


FIG. 8

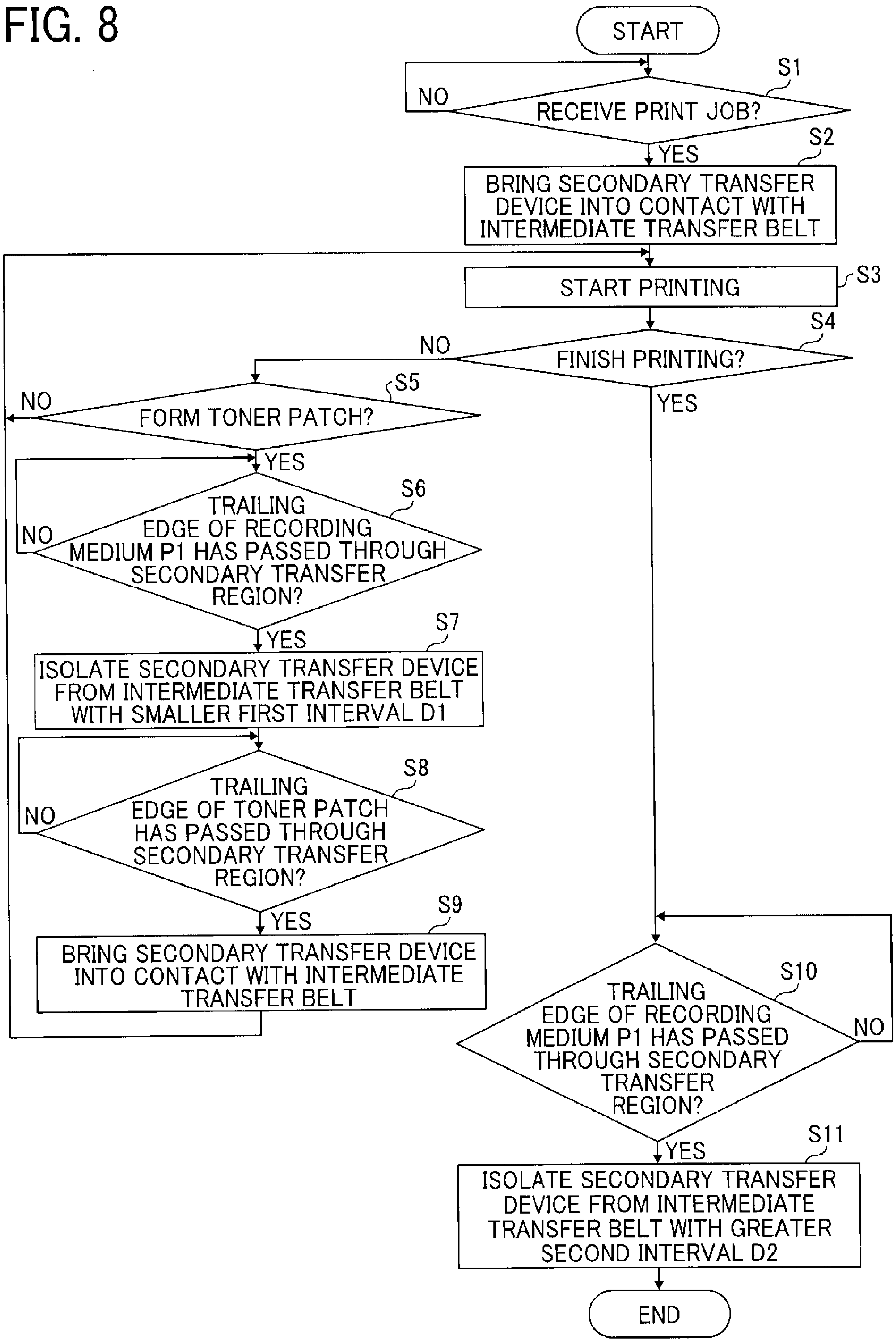

START
S1
NO
RECEIVE PRINT JOB?
YES
S2
BRING SECONDARY TRANSFER DEVICE INTO CONTACT WITH INTERMEDIATE TRANSFER BELT
S3
START PRINTING
S4
NO
FINISH PRINTING?
YES
S5
NO
FORM TONER PATCH?
YES
S6
NO
TRAILING EDGE OF RECORDING MEDIUM P1 HAS PASSED THROUGH SECONDARY TRANSFER REGION?
YES
S7
ISOLATE SECONDARY TRANSFER DEVICE FROM INTERMEDIATE TRANSFER BELT WITH SMALLER FIRST INTERVAL D1
S8
NO
TRAILING EDGE OF TONER PATCH HAS PASSED THROUGH SECONDARY TRANSFER REGION?
YES
S9
BRING SECONDARY TRANSFER DEVICE INTO CONTACT WITH INTERMEDIATE TRANSFER BELT
S10
TRAILING EDGE OF RECORDING MEDIUM P1 HAS PASSED THROUGH SECONDARY TRANSFER REGION?
NO
YES
S11
ISOLATE SECONDARY TRANSFER DEVICE FROM INTERMEDIATE TRANSFER BELT WITH GREATER SECOND INTERVAL D2
END

FIG. 9

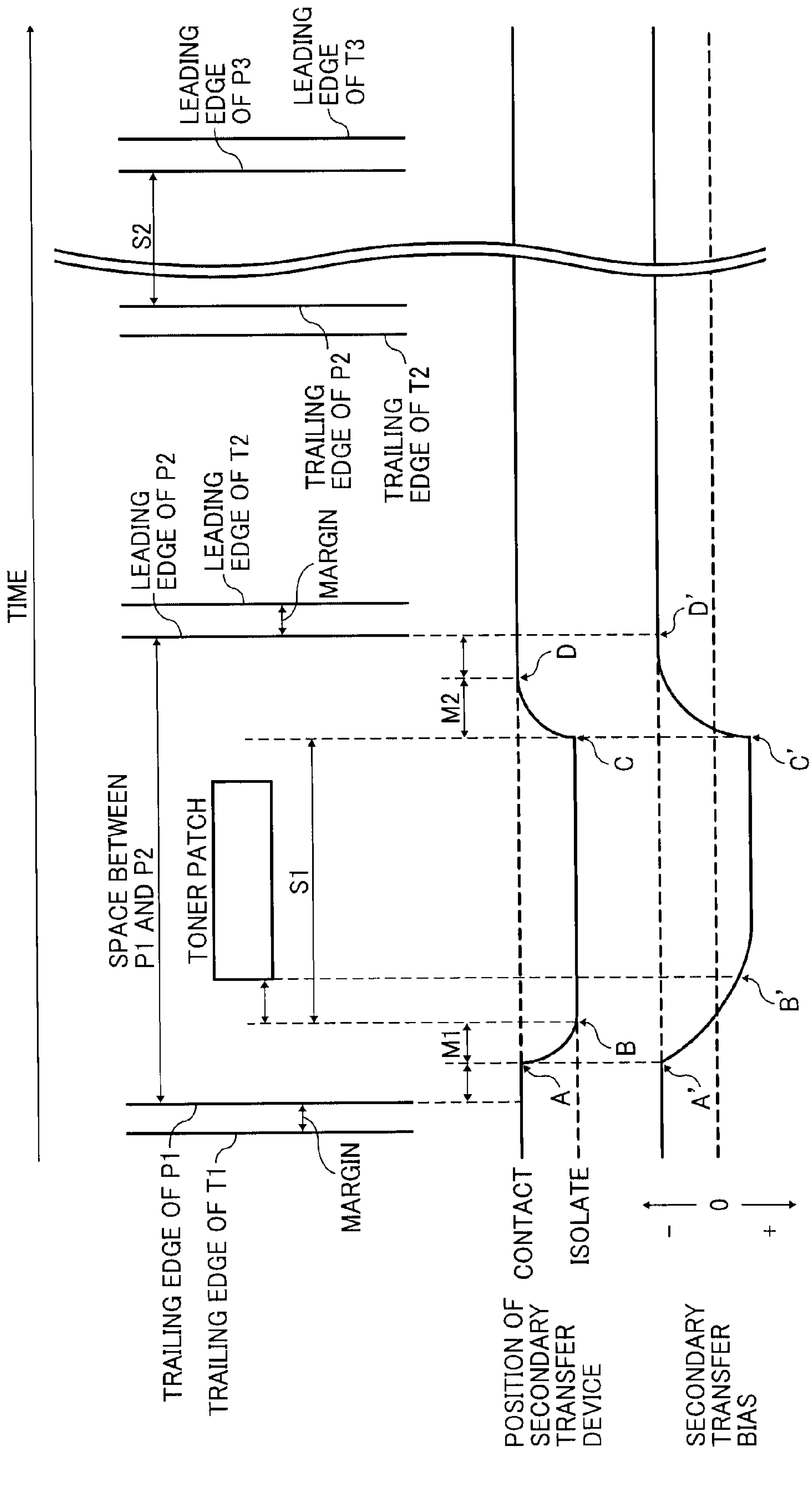

TIME
TRAILING EDGE OF P1
TRAILING EDGE OF T1
MARGIN
SPACE BETWEEN P1 AND P2
TONER PATCH
S1
M1
M2
LEADING EDGE OF P2
LEADING EDGE OF T2
MARGIN
TRAILING EDGE OF P2
TRAILING EDGE OF T2
S2
LEADING EDGE OF P3
LEADING EDGE OF T3
POSITION OF SECONDARY TRANSFER DEVICE
CONTACT
ISOLATE
A
B
C
D
SECONDARY TRANSFER BIAS
-
0
+
A'
B'
C'
D'

FIG. 10

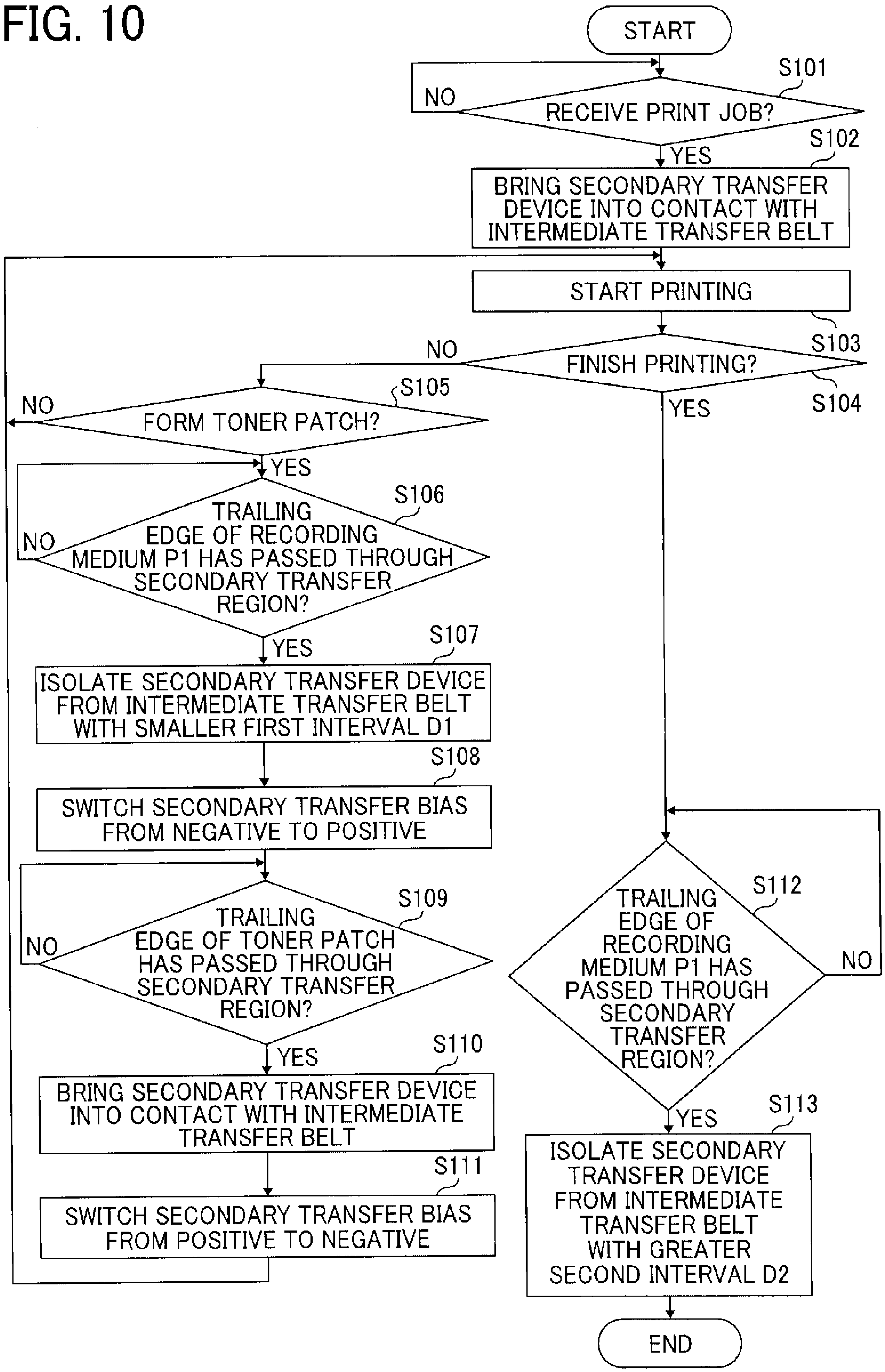

START
S101
NO
RECEIVE PRINT JOB?
YES
S102
BRING SECONDARY TRANSFER DEVICE INTO CONTACT WITH INTERMEDIATE TRANSFER BELT
START PRINTING
S103
NO
FINISH PRINTING?
S104
YES
S105
NO
FORM TONER PATCH?
YES
S106
NO
TRAILING EDGE OF RECORDING MEDIUM P1 HAS PASSED THROUGH SECONDARY TRANSFER REGION?
YES
S107
ISOLATE SECONDARY TRANSFER DEVICE FROM INTERMEDIATE TRANSFER BELT WITH SMALLER FIRST INTERVAL D1
S108
SWITCH SECONDARY TRANSFER BIAS FROM NEGATIVE TO POSITIVE
S109
NO
TRAILING EDGE OF TONER PATCH HAS PASSED THROUGH SECONDARY TRANSFER REGION?
YES
S110
BRING SECONDARY TRANSFER DEVICE INTO CONTACT WITH INTERMEDIATE TRANSFER BELT
S111
SWITCH SECONDARY TRANSFER BIAS FROM POSITIVE TO NEGATIVE
S112
TRAILING EDGE OF RECORDING MEDIUM P1 HAS PASSED THROUGH SECONDARY TRANSFER REGION?
NO
YES
S113
ISOLATE SECONDARY TRANSFER DEVICE FROM INTERMEDIATE TRANSFER BELT WITH GREATER SECOND INTERVAL D2
END

FIG. 11

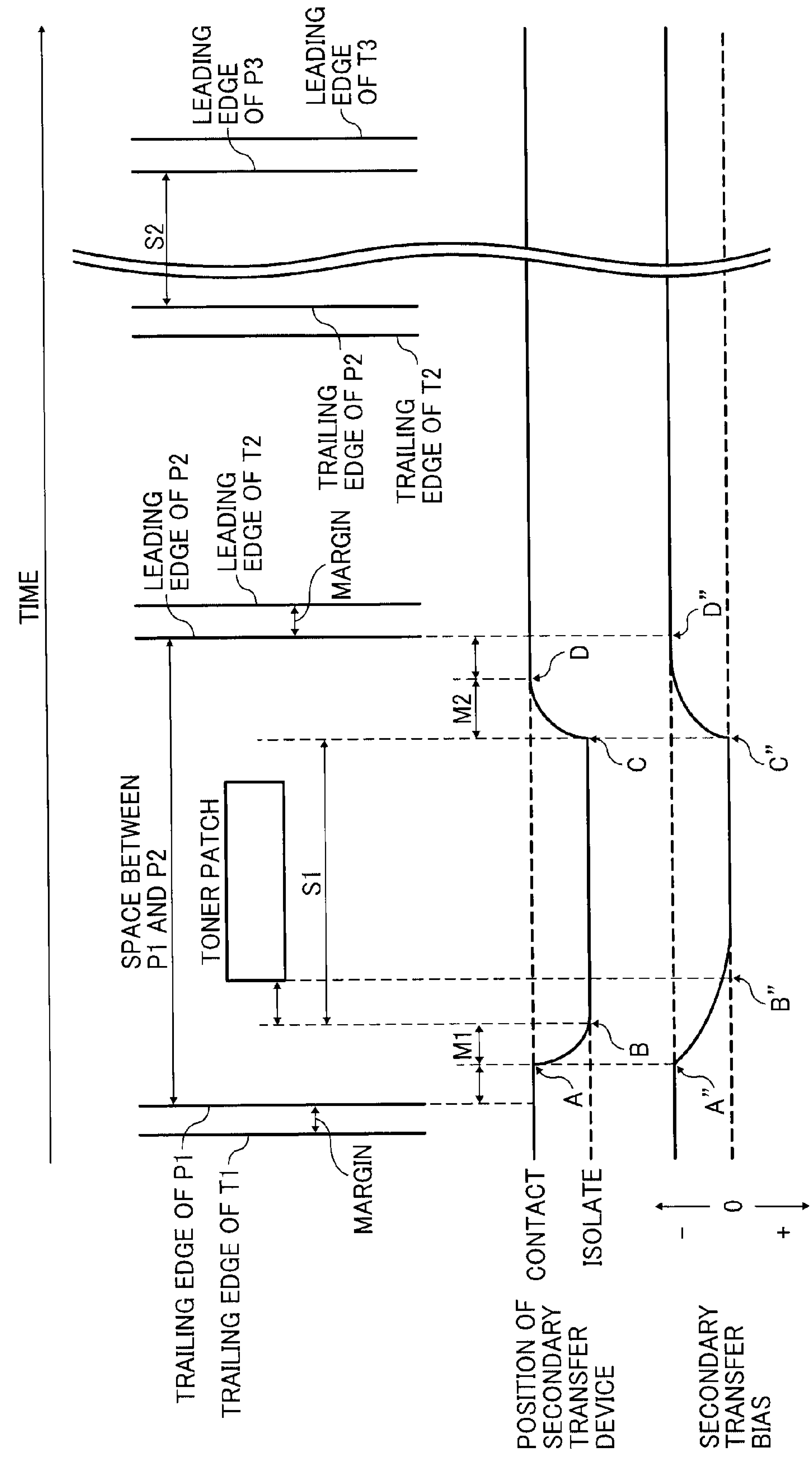

TIME
TRAILING EDGE OF P1
TRAILING EDGE OF T1
MARGIN
SPACE BETWEEN P1 AND P2
TONER PATCH
S1
M1
M2
LEADING EDGE OF P2
LEADING EDGE OF T2
MARGIN
TRAILING EDGE OF P2
TRAILING EDGE OF T2
S2
LEADING EDGE OF P3
LEADING EDGE OF T3
POSITION OF SECONDARY TRANSFER DEVICE
CONTACT
ISOLATE
A
B
C
D
SECONDARY TRANSFER BIAS
−
0
+
A"
B"
C"
D"

IMAGE FORMING APPARATUS WITH MECHANISM CAPABLE OF MOVING TRANSFER DEVICE WITH RESPECT TO TONER IMAGE CARRIER AND IMAGE FORMING METHOD FOR MOVING TRANSFER DEVICE WITH RESPECT TO TONER IMAGE CARRIER

CROSS-REFERENCE TO RELATED APPLICATION

This patent application is based on and claims priority pursuant to 35 U.S.C. §119 to Japanese Patent Application No. 2011-212692, filed on Sep. 28, 2011, in the Japanese Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Exemplary aspects of the present invention relate to an image forming apparatus and an image forming method, and more particularly, to an image forming apparatus for forming a toner image by transferring the toner image onto a recording medium directly or indirectly via an intermediate transferor and an image forming method employed by the image forming apparatus.

2. Description of the Related Art

Related-art image forming apparatuses, such as copiers, facsimile machines, printers, or multifunction printers having at least one of copying, printing, scanning, and facsimile functions, typically form an image on a recording medium according to image data. Thus, for example, a charger uniformly charges a surface of a photoconductor; an optical writer emits a light beam onto the charged surface of the photoconductor to form an electrostatic latent image on the photoconductor according to the image data; a development device supplies toner to the electrostatic latent image formed on the photoconductor to render the electrostatic latent image visible as a toner image; the toner image is primarily transferred from the photoconductor onto an intermediate transfer belt and secondarily transferred from the intermediate transfer belt onto a recording medium; finally, a fixing device applies heat and pressure to the recording medium bearing the toner image to fix the toner image on the recording medium, thus forming the image on the recording medium.

In order to form a toner image having a desired toner density, a toner patch is formed on the photoconductor, which is transferred onto the intermediate transfer belt. An optical sensor disposed opposite the intermediate transfer belt detects the toner density of the toner patch based on which image forming conditions such as the toner density of the toner image, the charging bias, and the development bias are adjusted. For example, if the image forming apparatus receives a multiple print job for forming a toner image on a plurality of recording media, the toner patch is created in a gap between successive toner images formed on the intermediate transfer belt. The toner image primarily transferred from the photoconductor onto the intermediate transfer belt is secondarily transferred onto the recording medium conveyed through a secondary transfer region formed between the intermediate transfer belt and a secondary transfer device pressed against the intermediate transfer belt. Since the toner patch should not be transferred onto the recording medium, no recording medium is conveyed through the secondary transfer region as the toner patch passes through the secondary transfer region. Accordingly, the toner patch created on the intermediate transfer belt may contact the secondary transfer device as it is conveyed through the secondary transfer region due to absence of the recording medium and toner may move from the toner patch to the secondary transfer device. Hence, as a subsequent recording medium is conveyed through the secondary transfer region, the toner may further move from the secondary transfer device to the back side of the subsequent recording medium that contacts the secondary transfer device, staining the subsequent recording medium.

To address this problem, a sensor disposed upstream from the secondary transfer region in a recording medium conveyance direction may detect absence of a recording medium conveyed toward the secondary transfer region. Whenever the sensor detects such absence of the recording medium, the secondary transfer device separates from the intermediate transfer belt so that the toner patch created on the intermediate transfer belt does not come into contact with the secondary transfer device as it is conveyed through the secondary transfer region, thus preventing adhesion of toner of the toner patch to the secondary transfer device.

However, since the secondary transfer device separates from the intermediate transfer belt whenever the sensor detects absence of the recording medium, the secondary transfer device comes into contact with and separates from the intermediate transfer belt repeatedly during the multiple print job for forming the toner image on the plurality of recording media. Since it takes time to bring the secondary transfer device into contact with and isolation from the intermediate transfer belt, an increased time may be consumed to finish the multiple print job, degrading productivity of the image forming apparatus.

To address this problem, the secondary transfer device may move with respect to the intermediate transfer belt at an increased speed. However, the secondary transfer device moving at the increased speed may vibrate the intermediate transfer belt, degrading the toner image formed on the intermediate transfer belt.

SUMMARY OF THE INVENTION

This specification describes below an improved image forming apparatus. In one exemplary embodiment of the present invention, the image forming apparatus includes a toner image carrier rotatable in a predetermined direction of rotation and carrying at least three, first to third toner images created successively thereon in the direction of rotation thereof to be transferred onto at least three successive recording media, respectively, as a print job, a toner patch section disposed between the first toner image and the second toner image and carrying a toner patch, and a blank section interposed between the second toner image and the third toner image. A transfer device separatably contacts the toner image carrier to form a transfer region therebetween through which the recording media are conveyed. A transfer device separator contacts and moves the transfer device between a contact position and a first isolation position within a shortened time, the contact position where the transfer device contacts the toner image carrier and the first isolation position where the transfer device is isolated from the toner image carrier with a first interval therebetween. A controller is operatively connected to the transfer device separator to control the transfer device separator to move the transfer device to the contact position as the first to third toner images and the blank section of the toner image carrier pass through the transfer region and to the first isolation position as the toner patch section of the toner image carrier passes through the transfer region.

This specification further describes an improved image forming method. In one exemplary embodiment of the present invention, the image forming method includes receiving a print job of forming at least three, first to third toner images on at least three, first to third recording media, respectively; bringing a transfer device into contact with a toner image carrier; forming the first toner image on the toner image carrier; forming a toner patch on the toner image carrier; transferring the first toner image formed on the toner image carrier onto the first recording medium conveyed through a transfer region formed between the transfer device and the toner image carrier; determining that a trailing edge of the first recording medium has passed through the transfer region; isolating the transfer device from the toner image carrier within a shortened time with an interval therebetween; determining that a trailing edge of the toner patch formed on the toner image carrier has passed through the transfer region; bringing the transfer device into contact with the toner image carrier; and transferring the second and third toner images from the toner image carrier onto the second and third recording media, respectively, conveyed through the transfer region.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and the many attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic vertical sectional view of an image forming apparatus according to an exemplary embodiment of the present invention;

FIG. **2** is a perspective view of a transfer unit incorporated in the image forming apparatus shown in FIG. **1**;

FIG. **3** is a partially enlarged vertical sectional view of a photoconductor and a toner density adjuster incorporated in the image forming apparatus shown in FIG. **1**;

FIG. **4**A is a vertical sectional view of an intermediate transfer belt, a secondary transfer device, and a secondary transfer device separator according to a first exemplary embodiment incorporated in the image forming apparatus shown in FIG. **1** in a state in which the secondary transfer device contacts the intermediate transfer belt;

FIG. **4**B is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and the secondary transfer device separator shown in FIG. **4**A in a state in which the secondary transfer device is isolated from the intermediate transfer belt;

FIG. **5** is a diagram illustrating a control method according to the first exemplary embodiment;

FIG. **6**A is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and a secondary transfer device separator according to a second exemplary embodiment incorporated in the image forming apparatus shown in FIG. **1** in a state in which the secondary transfer device contacts the intermediate transfer belt;

FIG. **6**B is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and the secondary transfer device separator shown in FIG. **6**A in a state in which the secondary transfer device is isolated from the intermediate transfer belt at a first isolation position;

FIG. **6**C is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and the secondary transfer device separator shown in FIG. **6**A in a state in which the secondary transfer device is isolated from the intermediate transfer belt at a second isolation position;

FIG. **7**A is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and a secondary transfer device separator according to a third exemplary embodiment incorporated in the image forming apparatus shown in FIG. **1** in a state in which the secondary transfer device contacts the intermediate transfer belt;

FIG. **7**B is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and the secondary transfer device separator shown in FIG. **7**A in a state in which the secondary transfer device is isolated from the intermediate transfer belt at a first isolation position;

FIG. **7**C is a vertical sectional view of the intermediate transfer belt, the secondary transfer device, and the secondary transfer device separator shown in FIG. **7**A in a state in which the secondary transfer device is isolated from the intermediate transfer belt at a second isolation position;

FIG. **8** is a flowchart illustrating first control processes for moving the secondary transfer device shown in FIGS. **6**A to **6**C with respect to the intermediate transfer belt;

FIG. **9** is a diagram of a control method according to a fourth exemplary embodiment;

FIG. **10** is a flowchart illustrating second control processes for moving the secondary transfer device shown in FIGS. **6**A to **6**C with respect to the intermediate transfer belt; and

FIG. **11** is a diagram of a comparative control method.

DETAILED DESCRIPTION OF THE INVENTION

In describing exemplary embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, in particular to FIG. **1**, an image forming apparatus **100** according to an exemplary embodiment of the present invention is explained.

FIG. **1** is a schematic vertical sectional view of the image forming apparatus **100**. The image forming apparatus **100** may be a copier, a facsimile machine, a printer, a multifunction printer having at least one of copying, printing, scanning, plotter, and facsimile functions, or the like. According to this exemplary embodiment, the image forming apparatus **100** is a tandem color copier for forming a color toner image on a recording medium by electrophotography. The image forming apparatus **100** employs an intermediate transfer method using an intermediate transfer belt **10** serving as a toner image carrier that carries a toner image to be transferred onto a recording medium. The image forming apparatus **100** is constructed of a paper storage **2** disposed in a lower portion thereof, a body **1** disposed above the paper storage **2**, a scanner **3** disposed above the body **1**, and an auto document feeder (ADF) **4** disposed above the scanner **3**.

The body **1** includes a transfer unit **20** in substantially a center portion thereof. The transfer unit **20** incorporates the endless intermediate transfer belt **10** stretched over a driving roller **14** and support rollers **15** and **16**. As the driving roller **14** drives and rotates the intermediate transfer belt **10** clockwise in FIG. **1** in a rotation direction R1, the support rollers **15** and **16** are driven and rotated in accordance with rotation of the intermediate transfer belt **10** by friction therebetween. Downstream from the support roller **16** in the rotation direction R1 of the intermediate transfer belt **10** is a belt cleaner **17** that removes residual toner remaining on an outer circumferential surface of the intermediate transfer belt **10** after a toner image is transferred from the intermediate transfer belt **10** onto a recording medium as described below, thus rendering the intermediate transfer belt **10** to be ready for the next transfer operation.

Above the intermediate transfer belt **10** are four drum-shaped photoconductors **40**Y, **40**M, **40**C, and **40**K arranged along the rotation direction R**1** of the intermediate transfer belt **10**. The photoconductors **40**Y, **40**M, **40**C, and **40**K serve as electrostatic latent image carriers that carry electrostatic latent images and resultant yellow, magenta, cyan, and black toner images, respectively. The photoconductors **40**Y, **40**M, **40**C, and **40**K are rotatable counterclockwise in FIG. **1** and surrounded by chargers **60**Y, **60**M, **60**C, and **60**K, development devices **61**Y, **61**M, **61**C, and **61**K, primary transfer devices **62**Y, **62**M, **62**C, and **62**K, photoconductor cleaners **63**Y, **63**M, **63**C, and **63**K, and dischargers **64**Y, **64**M, **64**C, and **64**K, respectively. Above the photoconductors **40**Y, **40**M, **40**C, and **40**K is an exposure device **21**.

Below the intermediate transfer belt **10** is a secondary transfer device **22** serving as a transfer device or a secondary transferor. The secondary transfer device **22** is pressed against the support roller **16** via the intermediate transfer belt **10** to form a secondary transfer region N between the secondary transfer device **22** and the intermediate transfer belt **10**. As a recording medium is conveyed through the secondary transfer region N, the secondary transfer device **22** secondarily transfers the yellow, magenta, cyan, and black toner images formed on the intermediate transfer belt **10** onto the recording medium collectively, thus forming a color toner image on the recording medium.

Downstream from the secondary transfer device **22** in a recording medium conveyance direction is an endless conveyance belt **24** looped over a pair of rollers **23** that conveys the recording medium bearing the color toner image toward a fixing device **25** disposed downstream from the conveyance belt **24** in the recording medium conveyance direction. The fixing device **25** includes an endless fixing belt **26** and a pressing roller **27** pressed against the fixing belt **26** to form a fixing nip therebetween through which the recording medium is conveyed. As the recording medium is conveyed through the fixing nip, the fixing belt **26** and the pressing roller **27** apply heat and pressure to the recording medium, melting and fixing the color toner image on the recording medium. Below the secondary transfer device **22** is a reverse device **28** that reverses the recording medium conveyed from the fixing device **25** for duplex printing.

The following describes a copying operation of the image forming apparatus **100** having the structure described above to form a color toner image on a recording medium.

As a user places an original document on an original document tray **30** of the ADF **4** and presses a start button on a control panel disposed atop the body **1**, conveyance rollers of the ADF **4** automatically convey the original document onto an exposure glass **32** of the scanner **3** and the scanner **3** starts scanning the original document. Alternatively, as the user lifts the ADF **4**, places an original document on the exposure glass **32** manually, lowers the ADF **4** to press the original document against the exposure glass **32**, and presses the start button on the control panel, the scanner **3** starts scanning the original document. For example, as a first carriage **33** and a second carriage **34** of the scanner **3** move, a light source mounted on the first carriage **33** emits light onto the original document placed on the exposure glass **32**. A mirror mounted on the first carriage **33** deflects light reflected by the original document toward the second carriage **34**. A pair of mirrors mounted on the second carriage **34** deflects light by about 180 degrees toward a reading sensor **36** through an image forming lens **35** so that the reading sensor **36** reads an image on the original document into image data.

On the other hand, as the user presses the start button on the control panel, the intermediate transfer belt **10** starts rotating clockwise in FIG. **1** in the rotation direction R**1** and at the same time the photoconductors **40**Y, **40**M, **40**C, and **40**K start rotating counterclockwise in FIG. **1**. As the photoconductors **40**Y, **40**M, **40**C, and **40**K rotate, the chargers **60**Y, **60**M, **60**C, and **60**K uniformly charge the photoconductors **40**Y, **40**M, **40**C, and **40**K; the exposure device **3** emits laser beams onto the charged photoconductors **40**Y, **40**M, **40**C, and **40**K according to image data sent from the scanner **3**, thus forming electrostatic latent images thereon; and the development devices **61**Y, **61**M, **61**C, and **61**K develop the electrostatic latent images into yellow, magenta, cyan, and black toner images, respectively. Thereafter, the primary transfer devices **62**Y, **62**M, **62**C, and **62**K primarily transfer the yellow, magenta, cyan, and black toner images formed on the photoconductors **40**Y, **40**M, **40**C, and **40**K, respectively, onto the intermediate transfer belt **10** successively as the intermediate transfer belt **10** rotates in the rotation direction R**1** so that the yellow, magenta, cyan, and black toner images are superimposed on a same position on the intermediate transfer belt **10**, thus forming a color toner image thereon.

On the other hand, one of a plurality of paper trays **44** situated inside a paper bank **43** of the paper storage **2** is selected according to a print job input by the user using the control panel. Accordingly, a pickup roller **42** corresponding to the selected paper tray **44** picks up and feeds an uppermost recording medium from a plurality of recording media loaded on the paper tray **44**. A separation roller **45** separates the uppermost recording medium from other recording media and feeds the separated recording medium toward a conveyance path **46**. Conveyance roller pairs **47** convey the recording medium through the conveyance path **46** toward a conveyance path **48** situated inside the body **1**. As the recording medium comes into contact with a registration roller pair **49**, the registration roller pair **49** halts the recording medium temporarily. Alternatively, if the user places a plurality of recording media onto a bypass tray **51**, a rotating pickup roller **50** picks up and feeds an uppermost recording medium toward a separation roller **52**. The separation roller **52** separates the uppermost recording medium from other recording media and conveys the separated recording medium toward a conveyance path **53**. As the recording medium comes into contact with the registration roller pair **49**, the registration roller pair **49** halts the recording medium temporarily.

Whether the recording medium is sent from the paper tray **44** or the bypass tray **51**, the registration roller pair **49** resumes rotating at a time when the color toner image formed on the intermediate transfer belt **10** is transferred onto the recording medium conveyed through the secondary transfer region N formed between the intermediate transfer belt **10** and the secondary transfer device **22**. Thereafter, the conveyance belt **24** conveys the recording medium bearing the color toner image to the fixing device **25** where the fixing belt **26** and the pressing roller **27** apply heat and pressure to the recording medium, fixing the color toner image on the recording medium. Then, a switch pawl **55** guides the recording medium toward an output roller pair **56** that discharges the recording medium onto an output tray **57** where the recording media bearing the fixed toner image are stacked.

If the user selects duplex printing, the switch pawl **55** guides the recording medium bearing the color toner image on a front side thereof toward the reverse device **28** that reverses and feeds the recording medium toward the secondary transfer region N formed between the secondary transfer device **22** and the intermediate transfer belt **10**. As the recording medium is conveyed through the secondary transfer region N, another toner image is transferred from the intermediate transfer belt **10** onto a back side of the recording medium. After the recording medium is conveyed through the fixing device **25**, the switch pawl **55** guides the recording medium toward the output roller pair **56** that discharges the recording medium onto the output tray **57**. If the user selects monochrome printing, the support rollers **15** and **16** move to isolate the intermediate transfer belt **10** from the photoconductors **40**Y, **40**M, and **40**C so that only the photoconductor **40**K contacts the intermediate transfer belt **10** to allow the primary transfer device **62**K to transfer the black toner image formed on the photoconductor **40**K onto the intermediate transfer belt **10**. If the image forming apparatus **100** is a single drum image forming apparatus that incorporates a single photoconductor instead of a tandem image forming apparatus that incorporates the four photoconductors **40**Y, **40**M, **40**C, and **40**K shown in FIG. **1**, the image forming apparatus **100** forms a black toner image first to shorten a first print time required to output a recording medium bearing a toner image onto the output tray **57** after the image forming apparatus **100** receives a print job. Then, the image forming apparatus **100** forms yellow, magenta, and cyan toner images for a color print job.

Generally, the registration roller pair **49** is grounded. However, the registration roller pair **49** may be applied with a bias to remove paper dust produced from the recording medium. For example, if a conductive rubber roller having a diameter of about 18 mm and a surface layer coated with a conductive nitrile-butadiene rubber (NBR) having a thickness of about 1 mm is used as the registration roller pair **49** applied with a bias, since the conductive NBR has a volume resistivity of about 10^9 Ω·cm, the rubber roller contacting the front side of the recording medium bearing the toner image is applied with a voltage of about −800 V and the rubber roller contacting the back side of the recording medium not bearing the toner image is applied with a voltage of about +200 V. In the image forming apparatus **100** incorporating the intermediate transfer belt **10**, paper dust produced from the recording medium does not generally move to the photoconductors **40**Y, **40**M, **40**C, and **40**K. Accordingly, it is not necessary to take measures against paper dust that may be transferred onto the toner image. Consequently, the registration roller pair **49** can be grounded.

Further, the registration roller pair **49** is generally applied with a direct current bias. Alternatively, the registration roller pair **49** may be applied with an alternating current voltage having a direct current offset component to uniformly charge the recording medium. Accordingly, after the recording medium passes through the registration roller pair **49**, the front side of the recording medium is negatively charged slightly. To address this circumstance, it may be necessary to set a secondary transfer condition different from that for the registration roller pair **49** applied with no voltage to secondarily transfer the color toner image from the intermediate transfer belt **10** onto the recording medium.

Referring to FIGS. **1** and **2**, the following describes a toner sensor **5** disposed opposite the driving roller **14** via the intermediate transfer belt **10**.

As shown in FIG. **1**, the toner sensor **5** is disposed opposite the outer circumferential surface of the intermediate transfer belt **10** and serves as a toner detector that detects an amount of toner, that is, a density of toner, adhered to the outer circumferential surface of the intermediate transfer belt **10**. The toner sensor **5** is constructed of an infrared-emitting diode used as a light emitting portion and a photodiode used as a diffuse reflection light receiving portion. The toner sensor **5** outputs voltage according to an amount of light received.

FIG. **2** is a perspective view of the transfer unit **20**. As shown in FIG. **2**, a toner patch TP is created on the outer circumferential surface of the intermediate transfer belt **10** to adjust the density of toner adhered to the intermediate transfer belt **10**. Initially, a toner patch TP is formed on the respective photoconductors **40**Y, **40**M, **40**C, and **40**K and transferred onto the intermediate transfer belt **10** by the respective primary transfer devices **62**Y, **62**M, **62**C, and **62**K as the toner patch TP passes through a primary transfer nip formed between the respective photoconductors **40**Y, **40**M, **40**C, and **40**K and the intermediate transfer belt **10**. Thus, the toner patch TP adheres to the intermediate transfer belt **10**. Generally, a plurality of toner patches TP having different target densities is created for a plurality of colors of yellow, magenta, cyan, and black. The toner sensor **5** disposed opposite the intermediate transfer belt **10** detects the amount of toner, that is, the density of toner, of each toner patch TP. For example, the toner sensor **5** detects the amount of toner of the toner patch TP in a process control mode, that is, a toner density adjustment mode, different from the image forming operation described above or during the image forming operation of forming a toner image on a plurality of recording media continuously by using a gap between successive toner images, that is, between successive recording media, on the intermediate transfer belt **10**.

Referring to FIG. **3**, a description is now given of adjustment of image density, also referred to as a toner density, for a black toner image, as a representative example of the adjustment of image density.

Although not illustrated, the density of toner for cyan, magenta, and yellow is adjusted in the same manner. FIG. **3** is a partially enlarged vertical sectional view of the photoconductor **40**K and a toner density adjuster **95**.

As shown in FIG. **3**, a charging bias applicator **65** is connected to the charger **60**K; a development bias applicator **66** is connected to the development device **61**K; a toner supply unit **90**K incorporating a toner supply motor **91**K is connected to the development device **61**K. The toner density adjuster **95** is operatively connected to the charging bias applicator **65**, the development bias applicator **66**, and the toner supply motor **91**K of the toner supply unit **90**K.

The toner sensor **5** detects an amount of toner of the toner batch TP formed on the intermediate transfer belt **10**. Based on the result detected by the toner sensor **5**, the toner density adjuster **95** controls at least one of the charging bias applicator **65**, the development bias applicator **66**, and the toner supply motor **91**K of the toner supply unit **90**K to adjust the toner density of a toner image to be formed on the photoconductor **40**K. For example, when adjusting the density of the toner image using the charging bias applicator **65**, the toner density adjuster **95** controls the charging bias applicator **65** to adjust an amount of charging bias applied to the photoconductor **40**K. When adjusting the density of the toner image using the toner supply motor **91**K, the toner density adjuster **95** controls the toner supply motor **91**K to adjust an amount of toner supplied to the development device **61**K. When adjusting the density of the toner image using the development bias applicator **66**, the toner density adjuster **95** controls the development bias applicator **66** to adjust an amount of development bias applied to the photoconductor **40**K.

Referring to FIGS. **4**A and **4**B, the following describes a configuration of a secondary transfer device separator **70** incorporated in the image forming apparatus **100** depicted in FIG. **1** according to a first exemplary embodiment.

The secondary transfer device separator **70** moves the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

A detailed description is now given of a construction and an operation of the secondary transfer device separator **70**.

FIG. **4**A is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **70** that brings the secondary transfer device **22** into contact with the intermediate transfer belt **10** at a contact position. FIG. **4**B is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **70** that isolates the secondary transfer device **22** from the intermediate transfer belt **10** at an isolation position.

As shown in FIGS. **4**A and **4**B, the secondary transfer device separator **70** includes a cam **71** having an outer circumferential face that contacts a contact point S of the secondary transfer device **22**; a rotation shaft **71***a* supporting the cam **71**; and a driver **72** (e.g., a motor) connected to and rotating the rotation shaft **71***a*. The driver **72** is operatively connected to a controller **73**, that is, a central processing unit (CPU), provided with a random-access memory (RAM) and a read-only memory (ROM), for example. As the controller **73** drives the driver **72**, the driver **72** rotates the rotation shaft **71***a*, thus rotating the cam **71**. As a farthest face **71***b* of the cam **71** farthest from the rotation shaft **71***a* comes into contact with the contact point S of the secondary transfer device **22**, a secondary transfer roller **22***c* of the secondary transfer device **22** comes into contact with the intermediate transfer belt **10** at the contact position shown in FIG. **4**A. Conversely, as the cam **71** rotates from the contact position shown in FIG. **4**A by 180 degrees and thereby a closest face **71***c* of the cam **71** closest to the rotation shaft **71***a* comes into contact with the contact point S of the secondary transfer device **22**, the secondary transfer roller **22***c* of the secondary transfer device **22** is isolated from the intermediate transfer belt **10** at the isolation position shown in FIG. **4**B.

As the cam **71** rotates from the contact position shown in FIG. **4**A to the isolation position shown in FIG. **4**B, the secondary transfer device **22** keeps in contact with the outer circumferential face of the cam **71** by its weight. Accordingly, as the cam **71** rotates from the contact position shown in FIG. **4**A to the isolation position shown in FIG. **4**B, the secondary transfer device **22** rotates about a rotation shaft **22***a* clockwise in FIG. **4**A from the contact position shown in FIG. **4**A to the isolation position shown in FIG. **4**B.

Referring to FIG. **5**, the following describes a control method for moving the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

FIG. **5** is a diagram illustrating a time when first to third recording media P**1** to P**3** bearing first to third toner images T**1** to T**3**, respectively, and the toner patch TP formed on the intermediate transfer belt **10** pass through the secondary transfer region N and a time when the secondary transfer device **22** comes into contact with and isolation from the intermediate transfer belt **10**. According to the first exemplary embodiment, during a print job for forming a toner image on a plurality of recording media continuously (hereinafter referred to as a multiple print job), a toner patch TP is formed at a predetermined time in a gap between the successive toner images, that is, between the first toner image T**1** and the second toner image T**2**, on the intermediate transfer belt **10**. The toner sensor **5** depicted in FIG. **1** detects the toner patch TP, performing process control, that is, toner density adjustment. As the toner patch TP formed on the intermediate transfer belt **10** passes through the secondary transfer region N, no recording medium is conveyed through the secondary transfer region N. Hence, if the secondary transfer device **22** contacts the intermediate transfer belt **10** while the toner patch TP passes through the secondary transfer region N, the toner patch TP comes into contact with and adheres to the secondary transfer device **22**. If the adhered toner patch TP is transferred from the secondary transfer device **22** onto a recording medium coming into the secondary transfer region N, the toner patch TP adheres to and stains the back side of the recording medium.

To address this problem, the controller **73** controls the driver **72** to rotate the cam **71** as shown in FIG. **5**. Thus, while the toner patch TP, that is, toner not to be transferred onto a recording medium, passes through the secondary transfer region N, the cam **71** isolates the secondary transfer device **22** from the intermediate transfer belt **10** at the isolation position shown in FIG. **4**B.

For example, in a state in which the secondary transfer device **22** contacts the intermediate transfer belt **10** at the contact position shown in FIG. **4**A, immediately before a toner patch TP is formed on the intermediate transfer belt **10**, the first toner image T**1** formed on the intermediate transfer belt **10** is secondarily transferred onto the first recording medium P**1** conveyed through the secondary transfer region N. After a trailing edge of the first recording medium P**1** passes through the secondary transfer region N, the controller **73** controls the driver **72** to start rotating the cam **71** at a time A shown in FIG. **5**. Specifically, the controller **73** determines the time A to start rotating the cam **71** so that half-turn of the cam **71** is completed and therefore the secondary transfer device **22** is isolated from the intermediate transfer belt **10** at the isolation position shown in FIG. **4**B at a time B shown in FIG. **5** before a leading edge of the toner patch TP enters the secondary transfer region N. That is, the cam **71** moves from the contact position shown in FIG. **4**A to the isolation position shown in FIG. **4**B within a shortened time M**1**, thus isolating the secondary transfer device **22** from the intermediate transfer belt **10** quickly.

After a trailing edge of the toner patch TP passes through the secondary transfer region N, the controller **73** controls the driver **72** to start rotating the cam **71** at a time C shown in FIG. **5**. Specifically, the controller **73** determines the time C to start rotating the cam **71** so that half-turn of the cam **71** is completed and therefore the secondary transfer device **22** comes into contact with the intermediate transfer belt **10** at the contact position shown in FIG. **4**A at a time D shown in FIG. **5** before a leading edge of the second recording medium P**2** enters the secondary transfer region N. That is, the cam **71** moves from the isolation position shown in FIG. **4**B to the contact position shown in FIG. **4**A within a shortened time M**2**, bringing the secondary transfer device **22** into contact with the intermediate transfer belt **10**.

Accordingly, while a toner patch section S**1** on the intermediate transfer belt **10** defined as an interval between the time B and the time C passes through the secondary transfer region N, the secondary transfer device **22** is isolated from the intermediate transfer belt **10**. After the time D, the secondary transfer device **22** remains in contact with the intermediate transfer belt **10** while the second recording medium P**2**, a blank section S**2** on the intermediate transfer belt **10** without the toner patch TP interposed between the second recording medium P**2** and the third recording medium P**3**, and the third recording medium P**3** are conveyed through the secondary transfer region N.

Referring to FIGS. **6**A, **6**B, and **6**C, the following describes a configuration of a secondary transfer device separator **170** incorporated in the image forming apparatus **100** depicted in FIG. **1** according to a second exemplary embodiment.

The secondary transfer device separator **170** moves the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

A detailed description is now given of a construction and an operation of the secondary transfer device separator **170**.

FIG. **6**A is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **170** that brings the secondary transfer device **22** into contact with the intermediate transfer belt **10** at a contact position. FIG. **6**B is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **170** that isolates the secondary transfer device **22** from the intermediate transfer belt **10** at a first isolation position. FIG. **6**C is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **170** that isolates the secondary transfer device **22** from the intermediate transfer belt **10** at a second isolation position.

As shown in FIGS. **6**A to **6**C, the secondary transfer device separator **170** includes a cam **171** having an outer circumferential face that contacts the contact point S of the secondary transfer device **22**; a rotation shaft **171***a* supporting the cam **171**; and the driver **72** (e.g., a motor) connected to and rotating the rotation shaft **171***a*. The driver **72** is operatively connected to the controller **73**. As the controller **73** drives the driver **72**, the driver **72** rotates the rotation shaft **171***a*, thus rotating the cam **171**. Like the secondary transfer device separator **70** depicted in FIGS. **4**A and **4**B, the secondary transfer device separator **170** includes the cam **171** that rotates and moves the secondary transfer device **22** with respect to the intermediate transfer belt **10**. However, unlike the secondary transfer device separator **70**, the secondary transfer device separator **170** isolates the secondary transfer device **22** from the intermediate transfer belt **10** at two positions, that is, the first isolation position shown in FIG. **6**B where the secondary transfer device **22** is spaced apart from the intermediate transfer belt **10** with a first interval D**1** therebetween and the second isolation position shown in FIG. **6**C where the secondary transfer device **22** is spaced apart from the intermediate transfer belt **10** with a second interval D**2** therebetween. For example, as a farthest face **171***b* of the cam **171** farthest from the rotation shaft **171***a* comes into contact with the contact point S of the secondary transfer device **22**, the secondary transfer roller **22***c* of the secondary transfer device **22** comes into contact with the intermediate transfer belt **10** at the contact position shown in FIG. **6**A.

Conversely, as the cam **171** rotates clockwise or counterclockwise in FIG. **6**A by 180 degrees from the contact position shown in FIG. **6**A and thereby a closer face **171***c* of the cam **171** closer to the rotation shaft **171***a* than the farthest face **171***b* comes into contact with the contact point S of the secondary transfer device **22**, the secondary transfer roller **22***c* of the secondary transfer device **22** is isolated from the intermediate transfer belt **10** at the first isolation position shown in FIG. **6**B where the secondary transfer device **22** is spaced apart from the intermediate transfer belt **10** with the first interval D**1** therebetween. As the cam **171** rotates counterclockwise in FIG. **6**A by 90 degrees from the contact position shown in FIG. **6**A and thereby a closest face **171***d* of the cam **171** closest to the rotation shaft **171***a* comes into contact with the contact point S of the secondary transfer device **22**, the secondary transfer roller **22***c* of the secondary transfer device **22** is isolated from the intermediate transfer belt **10** at the second isolation position shown in FIG. **6**C where the secondary transfer device **22** is spaced apart from the intermediate transfer belt **10** with the second interval D**2** greater than the first interval D**1** therebetween. A length L**1** from the rotation shaft **171***a* to the closer face **171***c* shown in FIG. **6**B is greater than a length L**2** from the rotation shaft **171***a* to the closest face **171***d* shown in FIG. **6**C. Hence, the first interval D**1** between the secondary transfer device **22** and the intermediate transfer belt **10** produced when the closer face **171***c* of the cam **171** contacts the contact point S of the secondary transfer device **22** is smaller than the second interval D**2** between the secondary transfer device **22** and the intermediate transfer belt **10** produced when the closest face **171***d* of the cam **171** contacts the contact point S of the secondary transfer device **22**.

Since the cam **171** is rotatable clockwise and counterclockwise in FIG. **6**A, the cam **171** moves the secondary transfer device **22** from any one of the contact position shown in FIG. **6**A, the first isolation position shown in FIG. **6**B, and the second isolation position shown in FIG. **6**C to any other one of them. According to the second exemplary embodiment, the cam **171** is shaped to have the farthest face **171***b*, the closer face **171***c*, and the closest face **171***d*. Accordingly, the cam **171** rotates clockwise or counterclockwise by 180 degrees from the contact position shown in FIG. **6**A where the farthest face **171***b* contacts the secondary transfer device **22**, thus moving to the first isolation position shown in FIG. **6**B where the closer face **171***c* contacts the secondary transfer device **22**. Further, the cam **171** rotates clockwise or counterclockwise by 90 degrees from the contact position shown in FIG. **6**A or the first isolation position shown in FIG. **6**B, thus moving to the second isolation position shown in FIG. **6**C where the closest face **171***d* contacts the secondary transfer device **22**. Alternatively, the cam **171** may be shaped otherwise.

Referring to FIGS. **7**A, **7**B, and **7**C, the following describes a configuration of a secondary transfer device separator **270** incorporated in the image forming apparatus **100** depicted in FIG. **1** according to a third exemplary embodiment.

The secondary transfer device separator **270** moves the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

A detailed description is now given of a construction and an operation of the secondary transfer device separator **270**.

FIG. **7**A is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **270** that brings the secondary transfer device **22** into contact with the intermediate transfer belt **10** at a contact position. FIG. **7**B is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **270** that isolates the secondary transfer device **22** from the intermediate transfer belt **10** at a first isolation position. FIG. **7**C is a vertical sectional view of the intermediate transfer belt **10**, the secondary transfer device **22**, and the secondary transfer device separator **270** that isolates the secondary transfer device **22** from the intermediate transfer belt **10** at a second isolation position.

Like the secondary transfer device separator **170** depicted in FIGS. **6**A to **6**C, the secondary transfer device separator **270** isolates the secondary transfer device **22** from the intermediate transfer belt **10** with the first interval D**1** and the second interval D**2** greater than the first interval D**1** therebetween. However, unlike the secondary transfer device separator **170**, the secondary transfer device separator **270** moves the secondary transfer device **22** by using two cams, that is, a first cam **271**A and a second cam **271**B.

For example, the secondary transfer device separator **270** is constructed of the first cam **271**A, the second cam **271**B, an arm **272**, and a compressing spring **273**. The first cam **271**A presses against a free end **272***b* of the arm **272**, that is, a left end in FIG. **7**A disposed downstream from the secondary transfer roller **22***c* in a recording medium conveyance direction C**1**. The arm **272** is swingable about a swing shaft **272***a* mounted on a fixed end **272***c* of the arm **272**, that is, a right end in FIG. **7**A disposed upstream from the secondary transfer roller **22***c* in the recording medium conveyance direction C**1**. A substantial center of the arm **272** in the recording medium conveyance direction C**1** contacts a roller shaft **22***b* of the secondary transfer roller **22***c* at each axial end of the secondary transfer roller **22***c* in an axial direction thereof. As the first cam **271**A rotates by 180 degrees from the contact position shown in FIG. **7**A to the first isolation position shown in FIG. **7**B and the second isolation position shown in FIG. **7**C, the first cam **271**A lowers the free end **272***b* of the arm **272** and therefore rotates the arm **272** about the swing shaft **272***a*. Accordingly, the arm **272** presses down the roller shaft **22***b* of the secondary transfer roller **22***c*, thus isolating the secondary transfer device **22** from the intermediate transfer belt **10**.

The second cam **271**B contacts the compression spring **273** anchored to a lower face **22***d* of the secondary transfer device **22**. The compression spring **273** constantly biases the secondary transfer device **22** upward. Accordingly, the roller shaft **22***b* of the secondary transfer roller **22***c* rotates the arm **272** to constantly move the free end **272***b* of the arm **272** upward, keeping the free end **272***b* of the arm **272** in contact with an outer circumferential face of the first cam **271**A.

As shown in FIG. **7**A, a first driver **74** (e.g., a motor) is connected to the first cam **271**A and a second driver **75** is connected to the second cam **271**B. The first driver **74** and the second driver **75** are operatively connected to the controller **73**. As the controller **73** controls the first driver **74** to rotate the first cam **271**A by 180 degrees from the contact position shown in FIG. **7**A where the secondary transfer device **22** contacts the intermediate transfer belt **10**, the first cam **271**A lowers the free end **272***b* of the arm **272** and the roller shaft **22***b* of the secondary transfer roller **22***c*, thus moving the secondary transfer device **22** to the first isolation position shown in FIG. **7**B where the secondary transfer device **22** is isolated from the intermediate transfer belt **10** with the first interval D**1** therebetween. At the first isolation position, since the compression spring **273** biases the secondary transfer device **22** upward, the roller shaft **22***b* of the secondary transfer roller **22***c* contacting the arm **272** retains the secondary transfer roller **22***c* at the first isolation position shown in FIG. **7**B where the secondary transfer roller **22***c* is isolated from the intermediate transfer belt **10** with the first interval D**1** therebetween.

Conversely, as the controller **73** controls the second driver **75** to rotate the second cam **271**B by 180 degrees from the first isolation position shown in FIG. **7**B, a lower end of the compression spring **273** lowers and decreases an amount of compression of the compression spring **273**, thus decreasing bias of the compressing spring **273** that biases the secondary transfer device **22** upward. Accordingly, weight of the secondary transfer device **22** lowers an upper end of the compression spring **273**, thus retaining the secondary transfer device **22** at the second isolation position shown in FIG. **7**C where weight of the secondary transfer device **22** and bias of the compression spring **273** are balanced. Consequently, the secondary transfer device **22** moves to the second isolation position shown in FIG. **7**C where the secondary transfer device **22** is isolated from the intermediate transfer belt **10** with the second interval D**2** therebetween greater than the first interval D**1** created at the first isolation position shown in FIG. **7**B.

Referring to FIG. **8**, the following describes an example of a first control method for moving the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

It is to be noted that although the first control method below uses the secondary transfer device separator **170** shown in FIGS. **6**A to **6**C, basic processes of the first control method are also applicable to the secondary transfer device separator **70** shown in FIGS. **4**A and **4**B, the secondary transfer device separator **270** shown in FIGS. **7**A to **7**C, and other secondary transfer device separators.

FIG. **8** is a flowchart illustrating control processes of the first control method for moving the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

In step S**1**, the controller **73** receives a print job. If the controller **73** receives the print job (YES in step S**1**), the controller **73** controls the driver **72** to rotate the cam **171** clockwise in FIG. **6**C by 90 degrees from the second isolation position shown in FIG. **6**C to the contact position shown in FIG. **6**A to bring the secondary transfer device **22** into contact with the intermediate transfer belt **10** before the first recording medium P**1** enters the secondary transfer region N in step S**2**. In step S**3**, the controller **73** starts printing, that is, the image forming operation described above, on the first recording medium P**1**. In step S**4**, the controller **73** determines whether or not printing is finished, that is, whether or not there is a toner image to be transferred onto the intermediate transfer belt **10**. If the controller **73** determines that printing is finished (YES in step S**4**), the controller **73** determines whether or not a tailing edge of the first recording medium P**1** has passed through the secondary transfer region N in step S**10**. If the controller **73** determines that the trailing edge of the first recording medium P**1** has passed through the secondary transfer region N (YES in step S**10**), the controller **73** controls the driver **72** to rotate the cam **171** counterclockwise in FIG. **6**A by 90 degrees from the contact position shown in FIG. **6**A to the second isolation position shown in FIG. **6**C, isolating the secondary transfer device **22** from the intermediate transfer belt **10** with the greater second interval D**2** therebetween in step S**11**.

On the other hand, if the controller **73** determines that printing is not finished, that is, if the controller **73** determines that there is the subsequent, second toner image T**2** to be transferred onto the intermediate transfer belt **10** (NO in step S**4**), the controller **73** determines whether or not to form a toner patch TP on the intermediate transfer belt **10** in the toner patch section **51** thereon interposed between the first toner image T**1** transferred onto the first recording medium P**1** and the subsequent, second toner image T**2** to be transferred next onto the second recording medium P**2** in step S**5**. If the controller **73** determines not to form the toner patch TP (NO in step S**5**), the controller **73** starts transferring the second toner image T**2** onto the intermediate transfer belt **10** at a predetermined time. Even while the blank section S**2**, without the toner patch TP, on the intermediate transfer belt **10** interposed between the preceding, second toner image T**2** transferred onto the second recording medium P**2** and the subsequent, third toner image T**3** passes through the secondary transfer region N, the secondary transfer device **22** remains in contact with the intermediate transfer belt **10** at the contact position shown in FIG. **6**A. Accordingly, a passage time for which the blank section S**2** of the intermediate transfer belt **10** passes through the secondary transfer region N is not restricted by a speed at which the secondary transfer device separator **170** isolates the secondary transfer device **22** from the intermediate transfer belt **10**. Consequently, the passage time of the blank section S**2** of the intermediate transfer belt **10** is shortened to a period of time that is available in the image forming apparatus **100**.

If the controller **73** determines to form the toner patch TP and therefore the toner patch TP is created on the intermediate transfer belt **10** in the toner patch section S**1** between the first toner image T**1** already transferred onto the intermediate transfer belt **10** and the second toner image T**2** to be transferred onto the intermediate transfer belt **10** (YES in step S**5**), the controller **73** determines whether or not the tailing edge of the first recording medium P**1** bearing the first toner image T**1** has passed through the secondary transfer region N in step S**6**. If the controller **73** determines that the trailing edge of the first recording medium P**1** has passed through the secondary transfer region N (YES in step S**6**), the controller **73** controls the driver **72** to rotate the cam **171** counterclockwise in FIG. **6**A by 180 degrees from the contact position shown in FIG. **6**A to the first isolation position shown in FIG. **6**B within the shortened time M**1**, isolating the secondary transfer device **22** from the intermediate transfer belt **10** with the smaller first interval D**1** therebetween in step S**7** before the toner patch TP formed on the intermediate transfer belt **10** enters the secondary transfer region N.

In step S**8**, the controller **73** determines whether or not a trailing edge of the toner patch TP has passed through the secondary transfer region N. If the controller **73** determines that the trailing edge of the toner patch TP has passed through the secondary transfer region N (YES in step S**8**), the controller **73** controls the driver **72** to rotate the cam **171** clockwise in FIG. **6**B by 180 degrees from the first isolation position shown in FIG. **6**B to the contact position shown in FIG. **6**A within the shortened time M**2**, bringing the secondary transfer device **22** into contact with the intermediate transfer belt **10** in step S**9** before the subsequent, second recording medium P**2** enters the secondary transfer region N. Thereafter, the controller **73** starts transferring the second toner image T**2** from the intermediate transfer belt **10** onto the second recording medium P**2** at a predetermined time. While the toner patch TP formed in the toner patch section S**1** on the intermediate transfer belt **10** interposed between the first toner image T**1** transferred onto the first recording medium P**1** and the subsequent, second toner image T**2** passes through the secondary transfer region N, the secondary transfer device **22** remains in isolation from the intermediate transfer belt **10** at the first isolation position shown in FIG. **6**B. Accordingly, the toner patch TP does not come into contact with the secondary transfer device **22** and therefore toner of the toner patch TP does not adhere to the secondary transfer device **22**. Consequently, even if the subsequent, second recording medium P**2** passes through the secondary transfer region N, toner of the toner patch TP does not adhere to and stain the back side of the second recording medium P**2**.

Referring to FIG. **9**, the following describes a control method for moving the secondary transfer device **22** with respect to the intermediate transfer belt **10** according to a fourth exemplary embodiment.

It is to be noted that the control method described below is applicable to the secondary transfer device separator **70** shown in FIGS. **4**A and **4**B, the secondary transfer device separator **170** shown in FIGS. **6**A to **6**C, and the secondary transfer device separator **270** shown in FIGS. **7**A to **7**C.

According to the fourth exemplary embodiment, a secondary transfer bias applied at the secondary transfer region N is switched between a negative bias and a positive bias. As shown in FIGS. **4**A, **4**B, **6**A to **6**C, and **7**A to **7**C, a secondary transfer bias applicator **96** connected to the support roller **16** applies a secondary transfer bias to the support roller **16**. For example, while the secondary transfer device **22** is isolated from the intermediate transfer belt **10**, the secondary transfer region N is applied with a positive secondary transfer bias opposite a negative secondary transfer bias applied while the secondary transfer device **22** contacts the intermediate transfer belt **10** to transfer the toner image formed on the intermediate transfer belt **10** onto the recording medium. FIG. **9** is a diagram of a control method according to the fourth exemplary embodiment illustrating a time when the first to third recording media P**1** to P**3** bearing the first to third toner images T**1** to T**3** and the toner patch TP formed on the intermediate transfer belt **10** pass through the secondary transfer region N and a time when the secondary transfer device **22** comes into contact with and isolation from the intermediate transfer belt **10**.

Generally, the toner image formed on the intermediate transfer belt **10** is transferred onto the recording medium by two bias application methods. A first method is to apply a secondary transfer bias having a polarity identical to a polarity of toner to the support roller **16** contacting an inner circumferential surface of the intermediate transfer belt **10**. A second method is to apply a secondary transfer bias having a polarity opposite a polarity of toner to the secondary transfer device **22** contacting the back side of the recording medium. According to the fourth exemplary embodiment, the first method of applying a negative secondary transfer bias identical to the negative polarity of toner to the support roller **16** is employed. However, the second method is also applicable.

As shown in FIG. **9**, after the trailing edge of the preceding, first recording medium P**1** passes through the secondary transfer region N formed between the secondary transfer device **22** and the intermediate transfer belt **10**, the secondary transfer bias applied from the secondary transfer bias applicator **96** to the support roller **16** is switched from negative to positive at a time A'. Hence, by a time B' when the toner patch TP enters the secondary transfer region N, the secondary transfer bias has been turned positive. At a time C' when the toner patch TP has passed through the secondary transfer region N, the secondary transfer bias is switched from positive to negative. By a time D' before the leading edge of the subsequent, second recording medium P**2** enters the secondary transfer region N, the secondary transfer bias has been turned negative. That is, while the toner patch section S**1** on the intermediate transfer belt **10** defined as an interval between the time B and the time C passes through the secondary transfer region N, the secondary transfer device **22** is isolated from the intermediate transfer belt **10**. After the time D, the secondary transfer device **22** remains in contact with the intermediate transfer belt **10** while the second recording medium P**2**, the blank section S**2** on the intermediate transfer belt **10** without the toner patch TP interposed between the second recording medium P**2** and the third recording medium P**3**, and the third recording medium P**3** are conveyed through the secondary transfer region N.

Referring to FIG. **10**, the following describes an example of a second control method for moving the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

It is to be noted that although the second control method below uses the secondary transfer device separator **170** shown in FIGS. **6**A to **6**C, basic processes of the second control method are also applicable to the secondary transfer device separator **70** shown in FIGS. **4**A and **4**B, the secondary transfer device separator **270** shown in FIGS. **7**A to **7**C, and other secondary transfer device separators.

FIG. **10** is a flowchart illustrating control processes of the second control method for moving the secondary transfer device **22** with respect to the intermediate transfer belt **10**.

In step S**101**, the controller **73** receives a print job. If the controller **73** receives the print job (YES in step S**101**), the controller **73** controls the driver **72** to rotate the cam **171** clockwise in FIG. **6**C by 90 degrees from the second isolation position shown in FIG. **6**C to the contact position shown in

FIG. **6**A to bring the secondary transfer device **22** into contact with the intermediate transfer belt **10** before the first recording medium P**1** enters the secondary transfer region N in step S**102**. In step S**103**, the controller **73** starts printing, that is, the image forming operation described above, on the first recording medium P**1**. In step S**104**, the controller **73** determines whether or not printing is finished, that is, whether or not there is a toner image to be transferred onto the intermediate transfer belt **10**. If the controller **73** determines that printing is finished (YES in step S**104**), the controller **73** determines whether or not a tailing edge of the first recording medium P**1** has passed through the secondary transfer region N in step S**112**. If the controller **73** determines that the trailing edge of the first recording medium P**1** has passed through the secondary transfer region N (YES in step S**112**), the controller **73** controls the driver **72** to rotate the cam **171** counterclockwise in FIG. **6**A by 90 degrees from the contact position shown in FIG. **6**A to the second isolation position shown in FIG. **6**C, isolating the secondary transfer device **22** from the intermediate transfer belt **10** with the greater second interval D**2** therebetween in step S**113**.

On the other hand, if the controller **73** determines that printing is not finished, that is, if the controller **73** determines that there is the subsequent, second toner image T**2** to be transferred onto the intermediate transfer belt **10** (NO in step S**104**), the controller **73** determines whether or not to form a toner patch TP on the intermediate transfer belt **10** in the toner patch section **51** thereon interposed between the first toner image T**1** transferred onto the first recording medium P**1** and the subsequent, second toner image T**2** to be transferred next in step S**105**. If the controller **73** determines not to form the toner patch TP (NO in step S**105**), the controller **73** starts transferring the second toner image T**2** onto the intermediate transfer belt **10** at a predetermined time. Even while the blank section S**2**, without the toner patch TP, on the intermediate transfer belt **10** interposed between the preceding, second toner image T**2** transferred onto the second recording medium P**2** and the subsequent, third toner image T**3** passes through the secondary transfer region N, the secondary transfer device **22** remains in contact with the intermediate transfer belt **10** at the contact position shown in FIG. **6**A. Accordingly, a passage time for which the blank section S**2** of the intermediate transfer belt **10** passes through the secondary transfer region N is not restricted by a speed at which the secondary transfer device separator **170** isolates the secondary transfer device **22** from the intermediate transfer belt **10**. Consequently, the passage time of the blank section S**2** of the intermediate transfer belt **10** is shortened to a period of time that is available in the image forming apparatus **100**.

If the controller **73** determines to form the toner patch TP and therefore the toner patch TP is created on the intermediate transfer belt **10** in the toner patch section S**1** between the first toner image T**1** already transferred onto the intermediate transfer belt **10** and the second toner image T**2** to be transferred onto the intermediate transfer belt **10** (YES in step S**105**), the controller **73** determines whether or not the tailing edge of the first recording medium P**1** bearing the first toner image T**1** has passed through the secondary transfer region N in step S**106**. If the controller **73** determines that the trailing edge of the first recording medium P**1** has passed through the secondary transfer region N (YES in step S**106**), the controller **73** controls the driver **72** to rotate the cam **171** counterclockwise in FIG. **6**A by 180 degrees from the contact position shown in FIG. **6**A to the first isolation position shown in FIG. **6**B within the shortened time M**1**, isolating the secondary transfer device **22** from the intermediate transfer belt **10** with the smaller first interval D**1** therebetween in step S**107** before the toner patch TP formed on the intermediate transfer belt **10** enters the secondary transfer region N. Simultaneously, the secondary transfer bias applicator **96** switches the secondary transfer bias applied to the support roller **16** from negative to positive in step S**108**.

In step S**109**, the controller **73** determines whether or not a trailing edge of the toner patch TP has passed through the secondary transfer region N. If the controller **73** determines that the trailing edge of the toner patch TP has passed through the secondary transfer region N (YES in step S**109**), the controller **73** controls the driver **72** to rotate the cam **171** clockwise in FIG. **6**B by 180 degrees from the first isolation position shown in FIG. **6**B to the contact position shown in FIG. **6**A within the shortened time M**2**, bringing the secondary transfer device **22** into contact with the intermediate transfer belt **10** in step S**110** before the subsequent, second recording medium P**2** enters the secondary transfer region N. Simultaneously, the secondary transfer bias applicator **96** switches the secondary transfer bias applied to the support roller **16** from positive to negative in step S**111**.

Thereafter, the controller **73** starts transferring the second toner image T**2** from the intermediate transfer belt **10** onto the second recording medium P**2** at a predetermined time. While the toner patch TP formed in the toner patch section S**1** on the intermediate transfer belt **10** interposed between the first toner image T**1** transferred onto the first recording medium P**1** and the subsequent, second toner image T**2** passes through the secondary transfer region N, the secondary transfer device **22** remains in isolation from the intermediate transfer belt **10** at the first isolation position shown in FIG. **6**B. Accordingly, the toner patch TP does not come into contact with the secondary transfer device **22** and therefore toner of the toner patch TP does not adhere to the secondary transfer device **22**. Consequently, even if the subsequent, second recording medium P**2** passes through the secondary transfer region N, toner of the toner patch TP does not adhere to and stain the back side of the second recording medium P**2**.

Referring to FIG. **11**, the following describes a comparative control method for turning the secondary transfer bias off while the secondary transfer device **22** is isolated from the intermediate transfer belt **10** instead of applying the positive secondary transfer bias as shown in FIG. **9**.

FIG. **11** is a diagram of the comparative control method illustrating a time when the first to third recording media P**1** to P**3** bearing the first to third toner images T**1** to T**3** and the toner patch TP formed on the intermediate transfer belt **10** pass through the secondary transfer region N and a time when the secondary transfer device **22** comes into contact with and isolation from the intermediate transfer belt **10**.

As shown in FIG. **11**, after the trailing edge of the preceding, first recording medium P**1** passes through the secondary transfer region N formed between the secondary transfer device **22** and the intermediate transfer belt **10**, the secondary transfer bias is switched off at a time A". Hence, at a time B" when the toner patch TP enters the secondary transfer region N, the secondary transfer bias may not have reached zero. At a time C" when the toner patch TP has passed through the secondary transfer region N, the secondary transfer bias is switched on. By a time D" before the leading edge of the subsequent, second recording medium P**2** enters the secondary transfer region N, the secondary transfer bias has been turned negative.

Switching off the secondary transfer bias according to the comparative control method shown in FIG. **11** may take longer to turn the secondary transfer bias to zero based on performance of a power supply compared to the fourth exemplary embodiment shown in FIG. **9**. Further, the secondary transfer bias may not have reached zero at the time B" when the toner patch TP enters the secondary transfer region N. In this case, a potential difference between the intermediate transfer belt **10** and the secondary transfer device **22** may move and spatter toner onto the secondary transfer device **22**, thus staining the secondary transfer device **22** with toner.

To address this problem, according to the fourth exemplary embodiment shown in FIG. **9**, while the secondary transfer device **22** is isolated from the intermediate transfer belt **10** after the trailing edge of the preceding, first recording medium P**1** is discharged from the secondary transfer region N and before the leading edge of the subsequent, second recording medium P**2** enters the secondary transfer region N, the secondary transfer bias is switched to positive, that is, a polarity opposite the negative polarity of toner. Accordingly, an electric field is applied to the toner patch TP formed on the intermediate transfer belt **10** in a direction away from the secondary transfer device **22**. Accordingly, toner does not spatter from the intermediate transfer belt **10** onto the secondary transfer device **22** and stain the secondary transfer device **22**. Although it takes some time to switch the polarity of the secondary transfer bias based on performance of the power supply, the potential difference between the secondary transfer device **22** and the intermediate transfer belt **10** is turned to zero within a shortened time before the time B' shown in FIG. **9** compared to the comparative control method for turning the secondary transfer bias off as shown in FIG. **11**.

Generally, the secondary transfer bias is under constant current control to retain a predetermined transfer electric field even if the resistance of the recording medium and the secondary transfer device **22** changes. However, if the secondary transfer bias is switched from negative to positive while the secondary transfer device **22** is isolated from the intermediate transfer belt **10**, such isolation may obstruct or hinder passage of an electric current. Accordingly, if the positive secondary transfer bias applied while the secondary transfer device **22** is isolated from the intermediate transfer belt **10** is under constant current control, voltage is substantially increased for passage of a predetermined electric current. Consequently, the electric current may leak to an inappropriate location, degrading the toner image formed on the recording medium or damaging the components incorporated in the image forming apparatus **100**.

To address this problem, according to the fourth exemplary embodiment shown in FIG. **9**, the positive secondary transfer bias applied while the secondary transfer device **22** is isolated from the intermediate transfer belt **10** is constant voltage controlled, preventing the above-described problem due to abnormal increase of voltage and spattering of toner from the intermediate transfer belt **10** onto the secondary transfer device **22**.

The following describes advantages of the secondary transfer device separators **70**, **170**, and **270** and the control methods described above. As shown in FIGS. **1**, **4**A, **4**B, **6**A, **6**B, **6**C, **7**A, **7**B, and **7**C, the image forming apparatus **100** includes the intermediate transfer belt **10** serving as a toner image carrier that carries a toner image formed thereon according to image data; the secondary transfer device **22** serving as a transfer device separatably contacting the intermediate transfer belt **10** to form the secondary transfer region N therebetween; the registration roller pair **49** serving as a recording medium feeder that feeds a recording medium to the secondary transfer region N; and the secondary transfer device separator **70**, **170**, or **270** serving as a transfer device separator that moves the secondary transfer device **22** with respect to the intermediate transfer belt **10**. As the recording medium is conveyed through the secondary transfer region N formed between the intermediate transfer belt **10** and the secondary transfer device **22** by the secondary transfer device separator **70**, **170**, or **270** that brings the secondary transfer device **22** into contact with the intermediate transfer belt **10**, the toner image formed on the intermediate transfer belt **10** is transferred onto the recording medium, thus forming the toner image on the recording medium according to the image data.

If the image forming apparatus **100** receives a print job for forming a toner image on three or more recording media continuously, that is, a multiple print job, the image forming apparatus **100** forms a toner patch TP, that is, a non-transfer toner image not to be transferred onto a recording medium, on the intermediate transfer belt **10** at one of a plurality of gaps between successive toner images. The controller **73** controls the secondary transfer device separator **70**, **170**, or **270** to bring the secondary transfer device **22** into contact with the intermediate transfer belt **10** while the toner image formed on the intermediate transfer belt **10** is transferred onto the recording medium. Conversely, the controller **73** controls the secondary transfer device separator **70**, **170**, or **270** to isolate the secondary transfer device **22** from the intermediate transfer belt **10** while the toner patch TP interposed between the first toner image T**1** transferred onto the first recording medium P**1** and the second toner image T**2** to be transferred onto the second recording medium P**2** passes through the secondary transfer region N. Accordingly, the toner patch TP does not come into contact with the secondary transfer device **22** and therefore toner of the toner patch TP does not stain the secondary transfer device **22**. Consequently, even if the subsequent, second recording medium P**2** passes through the secondary transfer region N, toner does not adhere to and stain the back side of the subsequent, second recording medium P**2**.

When at least one gap between a preceding toner image and a subsequent toner image adjacent to the preceding toner image on the intermediate transfer belt **10** where no toner patch TP is formed passes through the secondary transfer region N, that is, when the blank section S**2** between the second recording medium P**2** and the third recording medium P**3** passes through the secondary transfer region N, the controller **73** controls the secondary transfer device separator **70**, **170**, or **270** to retain the secondary transfer device **22** in contact with the intermediate transfer belt **10** even during interval between a preceding transfer of transferring the second toner image T**2** onto the second recording medium P**2** and a subsequent transfer of transferring the third toner image T**3** onto the third recording medium P**3**, not isolating the secondary transfer device **22** from the intermediate transfer belt **10**. Accordingly, the gap between the successive toner images on the intermediate transfer belt **10** that carries no toner patch TP, that is, the blank section S**2** interposed between the second toner image T**2** and the third toner image T**3**, remains in contact with the secondary transfer device **22**, eliminating a time required to isolate the secondary transfer device **22** from the intermediate transfer belt **10** and thus shortening a time for which the gap between the successive toner images, that is, the blank section S**2** interposed between the second toner image T**2** and the third toner image T**3**, passes through the secondary transfer region N regardless of the speed at which the secondary transfer device separator **70**, **170**, or **270** isolates the secondary transfer device **22** from the intermediate transfer belt **10**.

That is, compared to conventional image forming apparatuses in which all of the gaps between the successive toner images pass through the secondary transfer region N for an extended time increased by the speed at which the secondary transfer device **22** is isolated from the intermediate transfer belt **10**, the image forming apparatus **100** shortens the time required to complete the multiple print job, improving productivity of the image forming apparatus **100**. For example, a passage time required for the gap between the successive toner images on the intermediate transfer belt **10** that carries no toner patch TP, that is, the blank section S**2** interposed between the second toner image T**2** and the third toner image T**3**, to pass through the secondary transfer region N in a state in which the secondary transfer device **22** contacts the intermediate transfer belt **10** is shorter than a passage time required for the gap between the successive toner images on the intermediate transfer belt **10** that carries the toner patch TP, that is, the toner patch section S**1** interposed between the first toner image T**1** and the second toner image T**2**, to pass through the secondary transfer region N in a state in which the secondary transfer device **22** is isolated from the intermediate transfer belt **10**, thus shortening the time required to complete the multiple print job and improving productivity of the image forming apparatus **100**.

As shown in FIGS. **6**A to **7**C, the secondary transfer device separators **170** and **270** isolate the secondary transfer device **22** from the intermediate transfer belt **10** with at least two switchable intervals therebetween, that is, the first interval D**1** and the second interval D**2** greater than the first interval D**1**. The controller **73** controls the secondary transfer device separators **70**, **170**, and **270** to move the secondary transfer device **22** with respect to the intermediate transfer belt **10** even at a predetermined time other than a multiple print job, for example, immediately after such multiple print job is finished.

In order to isolate the secondary transfer device **22** from the intermediate transfer belt **10** during passage of the toner patch TP through the secondary transfer region N, the controller **73** controls the secondary transfer device separator **70**, **170**, or **270** to isolate the secondary transfer device **22** from the intermediate transfer belt **10** with the first interval D**1** smaller than the second interval D**2** with which the secondary transfer device **22** is isolated from the intermediate transfer belt **10** immediately after a multiple print job is finished. Accordingly, control for isolating the secondary transfer device **22** from the intermediate transfer belt **10** while the toner patch TP passes through the secondary transfer region N shortens the time required to isolate the secondary transfer device **22** from the intermediate transfer belt **10** compared to control for isolating the secondary transfer device **22** from the intermediate transfer belt **10** immediately after a multiple print job is finished. Consequently, the time required to complete a multiple print job is shortened, improving productivity of the image forming apparatus **100**.

According to the above-described exemplary embodiments, immediately after a multiple print job is finished, toner contained in the development devices **61**Y, **61**M, **61**C, and **61**K depicted in FIG. **1** is discharged to replace waste toner with fresh toner. The discharged waste toner is supplied from the development devices **61**Y, **61**M, **61**C, and **61**K onto the photoconductors **40**Y, **40**M, **40**C, and **40**K, respectively, and is further transferred from the photoconductors **40**Y, **40**M, **40**C, and **40**K onto the intermediate transfer belt **10**. Then, the belt cleaner **17** for cleaning the intermediate transfer belt **10** collects the transferred waste toner from the intermediate transfer belt **10**. An amount of waste toner transferred onto the intermediate transfer belt **10** is substantially greater than an amount of toner of the toner patch TP.

As described above, the secondary transfer device **22** is isolated from the intermediate transfer belt **10** with the smaller first interval D**1** therebetween while the toner patch TP passes through the secondary transfer region N to prevent adhesion of toner of the toner patch TP to the secondary transfer device **22** and at the same time shorten the time to isolate the secondary transfer device **22** from the intermediate transfer belt **10**. However, if the secondary transfer device **22** is isolated from the intermediate transfer belt **10** with the smaller first interval D**1** therebetween even while the waste toner discharged from the development devices **61**Y, **61**M, **61**C, and **61**K and transferred onto the intermediate transfer belt **10** passes through the secondary transfer region N, the waste toner of which amount is greater than the amount of toner of the toner patch TP may adhere to the secondary transfer device **22**.

To address this problem, the secondary transfer device separators **170** and **270** depicted in FIGS. **6**A to **7**C isolate the secondary transfer device **22** from the intermediate transfer belt **10** with the two switchable intervals, that is, the first interval D**1** and the second interval D**2** therebetween, thus minimizing adhesion of the waste toner to the secondary transfer device **22** immediately after a multiple print job is finished while preventing adhesion of toner of the toner patch TP to the secondary transfer device **22** and at the same time shortening the time to isolate the secondary transfer device **22** from the intermediate transfer belt **10**.

The secondary transfer device separators **170** and **270** move the secondary transfer device **22** from the first isolation position shown in FIGS. **6**B and **7**B or the second isolation position shown in FIGS. **6**C and **7**C to the contact position shown in FIGS. **6**A and **7**A and vise versa with a single motion, that is, a single movement of the cams **171**, **271**A, and **271**B, with the simple configuration of the secondary transfer device separators **170** and **270**. For example, as shown in FIGS. **6**A to **6**C, the secondary transfer device separator **170** includes the cam **171** having the farthest face **171***b*, the closer face **171***c*, and the closest face **171***d* that contact the contact point S on the secondary transfer device **22** and the driver **72** that rotates the cam **171** to the contact position, the first isolation position, and the second isolation position. As shown in FIGS. **7**A to **7**C, the secondary transfer device separator **270** includes the first cam **271**A and the second cam **271**B that press against the secondary transfer device **22**, the first driver **74** that rotates the first cam **271**A, and the second driver **75** that rotates the second cam **271**B. Thus, the secondary transfer device separators **170** and **270** are simplified.

In order to form a toner image on a thick recording medium, before a leading edge of the thick recording medium enters the secondary transfer region N, the controller **73** controls the driver **72**, the first driver **74**, and the second driver **75** to rotate the secondary transfer device separators **70**, **170**, and **270**, thus isolating the secondary transfer device **22** from the intermediate transfer belt **10** at the first isolation position shown in FIGS. **4**B, **6**B, and **7**B where the toner patch TP passes through the secondary transfer region N. After the leading edge of the thick recording medium enters the secondary transfer region N, the controller **73** controls the driver **72**, the first driver **74**, and the second driver **75** to rotate the secondary transfer device separators **70**, **170**, and **270**, thus bringing the secondary transfer device **22** into contact with the intermediate transfer belt **10**.

As the rigid, thick recording medium enters the secondary transfer region N while the secondary transfer device **22** contacts the intermediate transfer belt **10**, the leading edge of the thick recording medium strikes the intermediate transfer device **22** at an entry to the secondary transfer region N with substantial vibration transmitted to the intermediate transfer belt **10**, degrading the toner image formed on the intermediate transfer belt **10**. To address this problem, the secondary transfer device separators **70**, **170**, and **270** isolate the secondary transfer device **22** from the intermediate transfer belt **10** as the thick recording medium enters the secondary transfer region N, preventing the leading edge of the thick recording medium from striking the secondary transfer device **22** at the entry to the secondary transfer region N. Accordingly, the thick recording medium does not vibrate the intermediate transfer belt **10**, preventing formation of a faulty toner image due to vibration of the intermediate transfer belt **10**.

The toner patch TP created in the gap between the successive toner images, that is, the toner patch section S**1** interposed between the first toner image T**1** and the second toner image T**2**, on the intermediate transfer belt **10** during a multiple print job is a toner pattern used to adjust the density of toner of the toner images. The toner sensor **5** depicted in FIG. **1** serving as a toner detector detects an amount of toner of the toner pattern adhered to the intermediate transfer belt **10** so that adjustment of the density of the toner images, that is, a process control, is performed by the toner density adjuster **95** depicted in FIG. **3** based on the amount of toner of the toner pattern detected by the toner sensor **5**. Thus, the density of the toner images is stabilized during a multiple print job. Further, the toner pattern does not adhere to the secondary transfer device **22**, preventing toner of the toner pattern from moving from the secondary transfer device **22** onto the back side of the subsequent, second recording medium P**2** conveyed through the secondary transfer region N.

As shown in FIG. **1**, the image forming apparatus **100** is a tandem color copier employing the intermediate transfer method. For example, the image forming apparatus **100** includes the plurality of photoconductors **40**Y, **40**M, **40**C, and **40**K serving as electrostatic latent image carriers that carry electrostatic latent images and resultant yellow, magenta, cyan, and black toner images; and the intermediate transfer belt **10** serving as a toner image carrier or an intermediate transferor that carries the yellow, magenta, cyan, and black toner images transferred and superimposed on the intermediate transfer belt **10**. The superimposed, yellow, magenta, cyan, and black toner images are formed into a color toner image and transferred onto a recording medium conveyed through the secondary transfer region N formed between the intermediate transfer belt **10** and the secondary transfer device **22**.

Yellow, magenta, cyan, and black toner patterns are created on the photoconductors **40**Y, **40**M, **40**C, and **40**K, respectively, and then transferred onto a single gap between successive toner images on the intermediate transfer belt **10**, that is, the toner patch section S**1** interposed between the first toner image T**1** and the second toner image T**2**. Accordingly, the number of gaps between successive toner images where the toner pattern is created during a multiple print job decreases, and instead the number of gaps between successive toner images where no toner pattern is created increases, thus shortening passage time for which the gaps between the successive toner images where the toner pattern is created pass through the secondary transfer region N and improving productivity of the image forming apparatus **100** during a multiple print job.

A plurality of toner sensors **5** may be provided to correspond to a plurality of toner patterns, that is, yellow, magenta, cyan, and black toner patterns, respectively. With a single toner sensor **5** configured to detect a plurality of toner patterns, it is necessary to arrange the plurality of toner patterns in the rotation direction R**1** of the intermediate transfer belt **10** in such a manner that the plurality of toner patterns travels under a detection region of the toner sensor **5** successively. In this case, it is necessary to lengthen the gap between the successive toner images where the plurality of toner patterns is created in the rotation direction R**1** of the intermediate transfer belt **10**, increasing the time for such longer gap to pass through the secondary transfer region N and thereby degrading productivity of the image forming apparatus **100**.

To address this problem, the plurality of toner sensors **5** allows the plurality of toner patterns to be arranged in a direction, that is, a width direction, orthogonal to the rotation direction R**1** of the intermediate transfer belt **10** in such a manner that the plurality of toner patterns travels under the detection region of the plurality of toner sensors **5**, respectively, at one time. Thus, the gap between the successive toner images where the plurality of toner patterns is created occupies a decreased length in the rotation direction R**1** of the intermediate transfer belt **10** compared to the configuration in which the single toner sensor **5** detects the plurality of toner patterns, thus retaining productivity of the image forming apparatus **100**.

As shown in FIG. **9**, while the toner patch TP created on the intermediate transfer belt **10** passes through the secondary transfer region N in a state in which the secondary transfer device **22** is isolated from the intermediate transfer belt **10**, the secondary transfer bias is switched to positive opposite to the negative polarity of toner of the toner patch TP. Accordingly, toner of the toner patch TP does not spatter from the intermediate transfer belt **10** onto the secondary transfer device **22**, preventing the toner from staining the secondary transfer device **22**. Further, the positive secondary transfer bias applied while the secondary transfer device **22** is isolated from the intermediate transfer belt **10** is constant voltage controlled to prevent toner of the toner patch TP from spattering from the intermediate transfer belt **10** onto the secondary transfer device **22**, minimizing abnormal voltage increase and resultant failures.

The above-described exemplary embodiments are also applicable to an image forming apparatus employing a direct transfer method in which a toner image formed on a photoconductor is directly transferred onto a recording medium.

The present invention has been described above with reference to specific exemplary embodiments. Note that the present invention is not limited to the details of the embodiments described above, but various modifications and enhancements are possible without departing from the spirit and scope of the invention. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein. For example, elements and/or features of different illustrative exemplary embodiments may be combined with each other and/or substituted for each other within the scope of the present invention.

What is claimed is:

1. An image forming apparatus comprising:

a toner image carrier rotatable in a predetermined direction of rotation and carrying at least three, first to third toner images created successively thereon in the direction of rotation thereof to be transferred onto at least three successive recording media, respectively, as a print job, a toner patch section disposed between the first toner image and the second toner image and carrying a toner patch, and a blank section interposed between the second toner image and the third toner image;

a transfer device separatably contacting the toner image carrier to form a transfer region therebetween through which the recording media are conveyed;

a transfer device separator contacting and moving the transfer device between a contact position and a first isolation position within a shortened time, the contact position where the transfer device contacts the toner image carrier and the first isolation position where the transfer device is isolated from the toner image carrier with a first interval therebetween; and

a controller operatively connected to the transfer device separator to control the transfer device separator to move the transfer device to the contact position as the first to third toner images and the blank section of the toner image carrier pass through the transfer region and to the first isolation position as the toner patch section of the toner image carrier passes through the transfer region based on a detection of the toner patch before the toner patch section passes through the transfer region.

2. The image forming apparatus according to claim **1**, wherein the controller retains the transfer device in contact with the toner image carrier as the blank section of the toner image carrier passes through the transfer region after the second toner image on the toner image carrier passes through the transfer region to cause a first time for which the blank section of the toner image carrier passes through the transfer region to be shorter than a second time for which the toner patch section of the toner image carrier passes through the transfer region.

3. The image forming apparatus according to claim **1**, wherein the transfer device separator further moves the transfer device to a second isolation position where the transfer device is isolated from the toner image carrier with a second interval therebetween greater than the first interval.

4. The image forming apparatus according to claim **3**, wherein the controller controls the transfer device separator to move the transfer device to the second isolation position when the print job is finished.

5. The image forming apparatus according to claim **3**, wherein the controller controls the transfer device separator to move the transfer device to the second isolation position when waste toner carried on the toner image carrier passes through the transfer region.

6. The image forming apparatus according to claim **3**, wherein the transfer device separator includes:

a cam contacting the transfer device; and

a driver connected to and rotating the cam to the contact position, the first isolation position, and the second isolation position.

7. The image forming apparatus according to claim **6**, wherein the transfer device separator moves the transfer device between the contact position, the first isolation position, and the second isolation position with a single movement of the cam.

8. The image forming apparatus according to claim **3**,

wherein the transfer device includes a transfer roller separatably contacting the toner image carrier,

wherein the transfer device separator includes:

an arm contacting the transfer roller of the transfer device;

a first cam contacting the arm and having a first farthest face with a greatest distance from a first rotation shaft thereof and a first closest face with a smallest distance from the first rotation shaft;

a compression spring anchored to a lower face of the transfer device to exert a bias to the transfer device;

a second cam contacting the compression spring and having a second farthest face with a greatest distance from a second rotation shaft thereof and a second closest face with a smallest distance from the second rotation shaft;

a first driver connected to and rotating the first cam; and

a second driver connected to and rotating the second cam, and

wherein as the first closest face of the first cam contacts the arm and the second farthest face of the second cam contacts the compressing spring, the transfer roller contacts the toner image carrier, as the first farthest face of the first cam contacts the arm and the second farthest face of the second cam contacts the compression spring, the transfer roller is isolated from the toner image carrier with the first interval therebetween, and as the first farthest face of the first cam contacts the arm and the second closest face of the second cam contacts the compression spring, the transfer roller is isolated from the toner image carrier with the second interval therebetween.

9. The image forming apparatus according to claim **1**, wherein the controller controls the transfer device separator to move the transfer device to the first isolation position before a leading edge of a thick recording medium enters the transfer region and to the contact position after the leading edge of the thick recording medium enters the transfer region.

10. The image forming apparatus according to claim **1**, further comprising:

a toner detector disposed opposite the toner image carrier to detect an amount of toner of the toner patch; and

a toner density adjuster connected to the toner detector to adjust a density of toner of the second and third toner images based on the amount of toner of the toner patch detected by the toner detector.

11. The image forming apparatus according to claim **10**, further comprising a plurality of electrostatic latent image carriers contacting the toner image carrier and carrying a plurality of toner patches, respectively, to be transferred onto the single toner patch section on the toner image carrier.

12. The image forming apparatus according to claim **11**, wherein the toner detector includes a plurality of toner sensors to detect the plurality of toner patches on the toner image carrier, respectively.

13. The image forming apparatus according to claim **1**, further comprising a support roller contacting the toner image carrier and disposed opposite the transfer device via the toner image carrier,

wherein the support roller is applied with a transfer bias having a polarity opposite a polarity of toner of the toner patch as the transfer device separator moves the transfer device to the first isolation position when the toner patch section of the toner image carrier passes through the transfer region.

14. The image forming apparatus according to claim **13**, wherein the transfer bias applied to the support roller as the transfer device separator moves the transfer device to the first isolation position is constant voltage controlled.

15. The image forming apparatus according to claim **1**, wherein the toner image carrier includes an endless intermediate transfer belt.

16. An image forming method comprising:

receiving a print job of forming at least three, first to third toner images on at least three, first to third recording media, respectively;

bringing a transfer device into contact with a toner image carrier;

forming the first toner image on the toner image carrier;

forming a toner patch on the toner image carrier;

detecting the toner patch on the image carrier;

transferring the first toner image formed on the toner image carrier onto the first recording medium conveyed through a transfer region formed between the transfer device and the toner image carrier;

determining that a trailing edge of the first recording medium has passed through the transfer region;

isolating the transfer device from the toner image carrier within a shortened time with an interval therebetween based on the detecting of the toner patch;

determining that a trailing edge of the toner patch formed on the toner image carrier has passed through the transfer region;

bringing the transfer device into contact with the toner image carrier; and

transferring the second and third toner images from the toner image carrier onto the second and third recording media, respectively, conveyed through the transfer region.

17. The image forming method according to claim **16**, further comprising switching a secondary transfer bias applied to the toner image carrier from negative to positive when isolating the transfer device from the toner image carrier within the shortened time with the interval therebetween.

18. The image forming method according to claim **17**, further comprising switching the secondary transfer bias applied to the toner image carrier from positive to negative when bringing the transfer device into contact with the toner image carrier.

19. An image forming apparatus comprising:

a toner image carrier rotatable in a predetermined direction of rotation and carrying at least three, first to third toner images created successively thereon in the direction of rotation thereof to be transferred onto at least three successive recording media, respectively, as a print job, a toner patch section disposed between the first toner image and the second toner image and carrying a toner patch, and a blank section interposed between the second toner image and the third toner image;

a transfer device separatably contacting the toner image carrier to form a transfer region therebetween through which the recording media are conveyed;

a transfer device separator contacting and moving the transfer device between a contact position and a first isolation position within a shortened time, the contact position where the transfer device contacts the toner image carrier and the first isolation position where the transfer device is isolated from the toner image carrier with a first interval therebetween; and

a controller operatively connected to the transfer device separator to control the transfer device separator to move the transfer device to the contact position as the first to third toner images and the blank section of the toner image carrier pass through the transfer region and to the first isolation position as the toner patch section of the toner image carrier passes through the transfer region,

wherein the controller retains the transfer device in contact with the toner image carrier as the blank section of the toner image carrier passes through the transfer region after the second toner image on the toner image carrier passes through the transfer region to cause a first time for which the blank section of the toner image carrier passes through the transfer region to be shorter than a second time for which the toner patch section of the toner image carrier passes through the transfer region.

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